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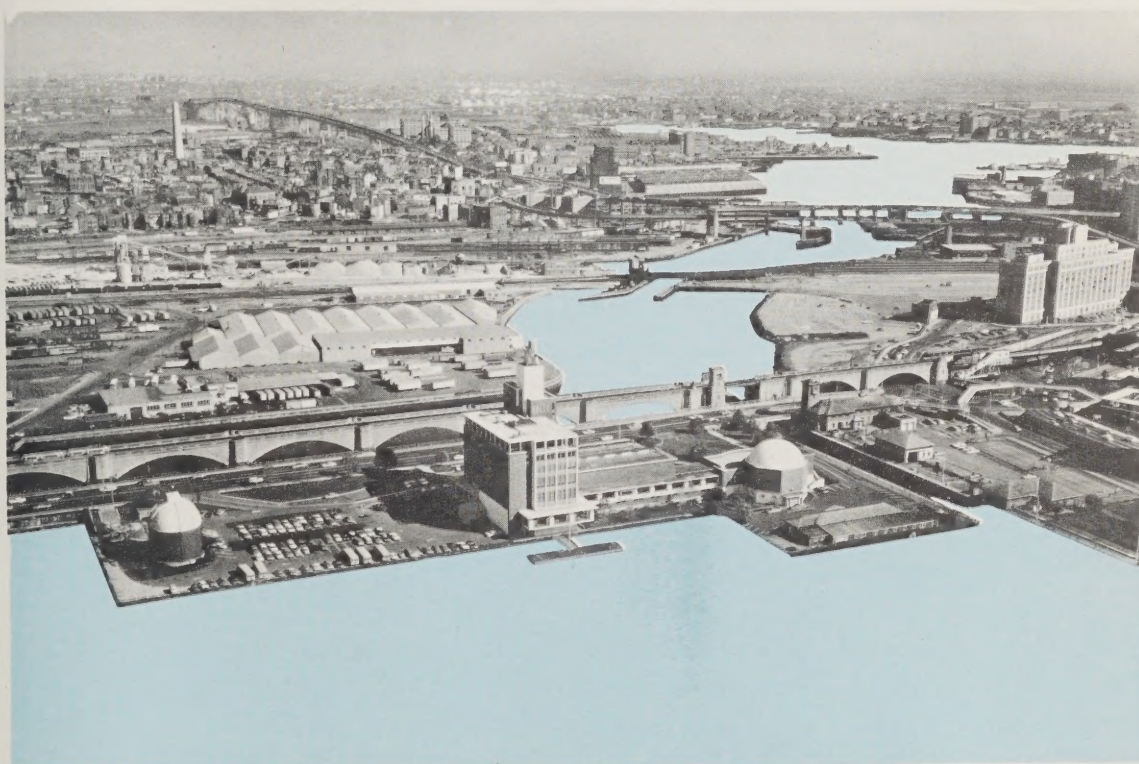
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WATER RESOURCES DEVELOPMENT

**INTERIM REPORT ON CHARLES RIVER
FOR FLOOD CONTROL AND NAVIGATION**

**LOWER CHARLES RIVER
MASSACHUSETTS**



**DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.**

MAY 1968

258

WATER RESOURCES DEVELOPMENT

INTERIM REPORT ON CHARLES RIVER
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LOWER CHARLES RIVER
MASSACHUSETTS

Department of the Army
New England Division, Corps of Engineers
Waltham, Mass.

May 1968

SYLLABUS

The existing Charles River Dam at Leverett Street, Boston completed by the Commonwealth of Massachusetts in 1910, impounds about 8.6 river miles to a point above Galen Street in Watertown. This dam was constructed for the purposes of preventing tidal flooding of the lowlands and sewers and drains along the lower reach of the Charles River and creating a constant level recreational pool, of aesthetic nature, that would cover unsightly tidal flats. The pool that was so created has become a major environmental feature of urban Boston and is known as the Charles River Basin. The dam includes a lock which allows passage of boats between the basin and Boston Harbor and sluice gates to discharge excess Basin inflow to tidewater.

The growth in metropolitan Boston over the past 50 years has resulted in the conversion of many former open areas to developed and paved areas. This change has increased the rapidity and amount of runoff to the 12 miles of the Charles River above the existing dam. The sluices and lock in the present dam are now inadequate to pass flood flows which would be experienced at the present time or the greater number of boats now using the Basin.

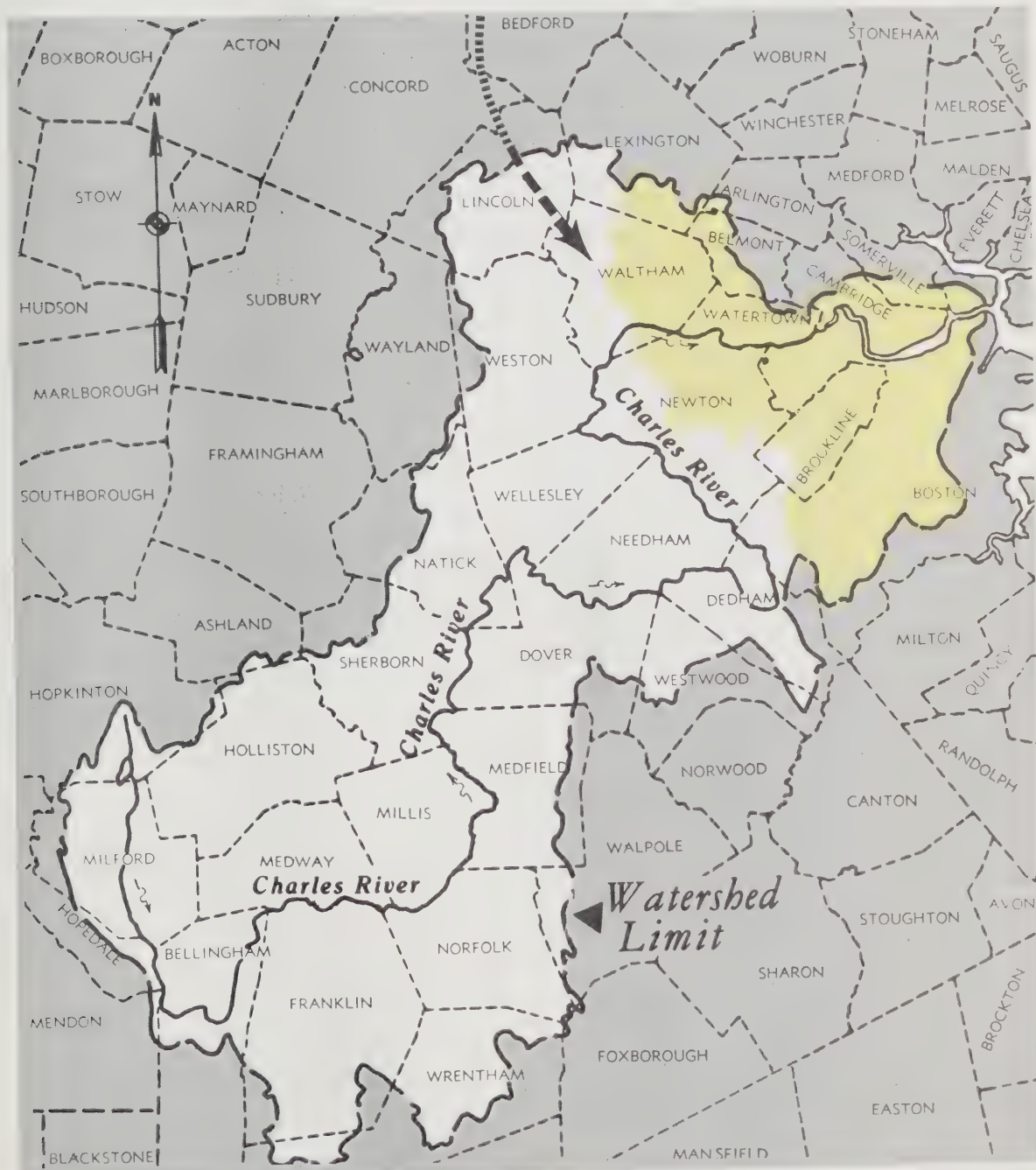
During the record flood in August 1955 serious damages, amounting to an estimated \$5.5 million, were experienced along the lower

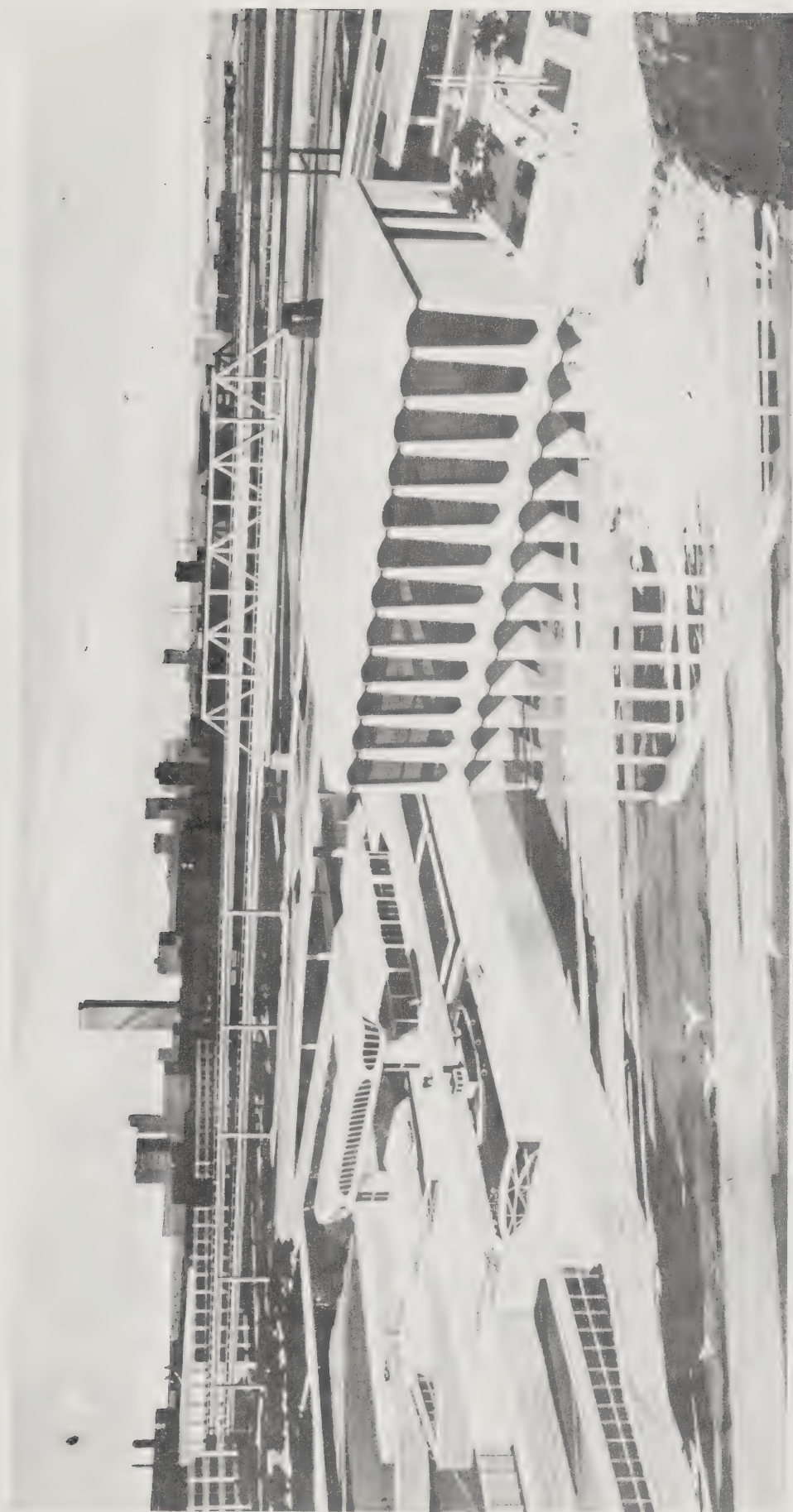
Charles River and its tributaries, especially in Boston and Cambridge. A repetition of the 1955 flood level today would cause \$12.4 million of loss at present prices.

The 1910 dam is inadequate to meet present and future flood control and navigation needs. It cannot be modified economically to meet those needs. Alternate structural and non-structural measures have been thoroughly investigated to conceive an optimum plan of water resource development in the lower Charles River.

The Division Engineer recommends, subject to a number of specific requirements of local cooperation, the construction of a new dam across the Charles River at Warren Avenue in Boston, with a pumping station, three locks, a highway viaduct, and appurtenant structures, to meet the needs of flood control, navigation, and highway transportation. The total first cost of the project, including necessary relocations and modifications to existing sewerage and drainage lines is \$26,500,000, of which \$18,620,000 is the Federal cost and \$7,880,000 the non-Federal cost. The annual cost for maintenance and operation of the project, which is an item of local responsibility, is estimated at \$184,000 including the cost of major replacements. The benefit to cost ratio is 1.9 to 1.0.

LOWER CHARLES INTERIM REPORT AREA





PROPOSED CHARLES RIVER BASIN FLOOD CONTROL PROJECT

CHARLES RIVER INTERIM REPORT

LOWER CHARLES RIVER

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ATTACHMENT I

Information Called for by Senate Resolution 148,
85th Congress, Adopted 28 January 1958

APPENDICES

A	Digest of Public Hearings
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D	Hydrology and Hydraulics
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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO

NEDED-R

29 May 1968

SUBJECT: Interim Report on Water Resources Development, Lower
Charles River Watershed, Mass.

TO: Chief of Engineers
ATTN: ENGCW-PD

AUTHORITY

1. This report is submitted in partial response to the following resolution of the Committee on Public Works of the House of Representatives, United States, adopted 24 June 1965:

"That the Board of Engineers for Rivers and Harbors is hereby requested to review the report on Land and Water Resources of the New England-New York Region printed in Senate Document Numbered 14, 85th Congress, First Session, with particular reference to the Charles River Basin and tributaries, Massachusetts, with a view to determining the advisability of improvements in the interest of flood control, water supply, recreation, water quality control, navigation, tidal flood control, allied purposes and related land resources."

A full report on the entire Charles River Watershed will follow at a later date.

EXTENT OF INVESTIGATION

2. SCOPE OF REPORT

This report, of survey scope, covers the drainage area of the 12.6 miles of the Charles River lying between its mouth at Boston Harbor and the Moody Street Dam in Waltham. It presents the results of studies with respect to flood control and navigation and gives detailed consideration to the construction of a dam with locks and a pumping station at

Warren Avenue, Boston, near the mouth of the river, to alleviate flooding and improve navigation. It also suggests improvements that may be accomplished to reduce flooding in the Back Bay Fens and along the lower Muddy River in Brookline and Boston. Information pertaining to pollution, sewerage, recreation, water supply, water quality control and other related land and water resources is inventoried and the general problems with respect to these subjects are discussed.

3. DESCRIPTIVE SUMMARY OF STUDIES

The report includes data on climatology, hydrology, navigation, and flooding and flood damages and a description, together with estimates of costs and benefits, of a plan of improvement. Field reconnaissances of the problem area and sites of potential improvements were made by the reporting officer and members of his staff. Field work has included an investigation, in late 1967 and early 1968, of flood damages in areas of Boston and Cambridge subject to flooding at times of high water in the Charles River Basin. No new topographic surveys were found to be necessary. U. S. Geological survey maps were available for general studies. Other topographic information was secured from recent maps and from plans for new highways, sewers, and other facilities that were made available by local agencies.

Information on subsurface conditions was derived from explorations made by others. Statistics on present and prospective boat traffic, commercial and recreational, including lockages at the present Charles River Dam, were compiled from recent reports by local interests. They were updated by field review and investigation. Sources of pollution along the river were located, identified, and analyzed as to nature of effluent by the Federal Water Pollution Control Administration of the Department of the Interior.

4. COORDINATION

The Division Engineer has been assigned the major responsibility for accomplishment of the study. To assist and furnish guidance and advice in the conduct of the study, a Coordinating Committee was formed consisting of representatives of the following Federal and state agencies:

Federal Agencies

Department of the Army (Chairman Agency)
Department of Agriculture

Federal Agencies (cont'd)

Department of the Interior
Department of Commerce
Department of Health, Education and Welfare
Department of Housing & Urban Development

Massachusetts Agencies (designated by Governor)

Department of Natural Resources
Metropolitan District Commission
Metropolitan Area Planning Council

Also, a Citizen Advisory Committee of 28 members, representing the cities and towns located wholly or partly in the watershed, was convened to provide local means of communication between watershed interest groups and the study agencies.

Three public hearings were held, one each in Waltham, Wellesley, and Franklin, in January 1967, for the purpose of determining the desires of local interests (See paragraph 35). During the course of the preparation of this report frequent conferences were held with staff members of local agencies such as the Boston Redevelopment Authority, the Public Works Department of Boston and Brookline, the Massachusetts Department of Public Works, the Metropolitan Area Planning Council and the Metropolitan District Commission for the purpose of determining the availability of basic data, and securing information on existing facilities and conditions and on considered improvements.

PRIOR REPORTS

5. FEDERAL

There are no previous reports by the Corps of Engineers on the specific subjects of flood control and navigation in the Charles River watershed. However, Part Two, Chapter XVI (unpublished) of the report (Senate Document No. 14, 85th Congress, 1st Session - the report under review) on the "Land and Water Resources of the New England-New York Region," prepared by the New England-New York Inter-Agency Committee, pursuant to Presidential directive of October 9, 1950, included basic material with respect to flooding, navigation, and pollution control in the watershed.

A letter-type (unpublished) report, entitled: "Reconnaissance Report-Local Protection, Muddy River, Boston-Brookline, Massachusetts," was submitted to the Chief of Engineers on 21 April 1966 pursuant to authority contained in Section 205 of Public Law 87-874, adopted 23 October 1962. The report includes a description of the area, presents material on stream characteristics, and discusses flooding and the flood problem in this tributary watershed. In view of the cost limitation contained in Section 205 of P.L. 87-874 and the close relationship between flood stages on the Muddy and Charles Rivers, the report recommended that flood protection investigations of the Muddy River be incorporated with the current Charles River Basin Study.

6. LOCAL

Numerous reports on the Charles River have been prepared by local agencies over the years. The following reports have been used most extensively in the course of this study:

- a. Report of Committee on Charles River Dam with Report of John R. Freeman, Chief Engineer, 1903.
- b. Annual Reports of Charles River Basin Commission, 1903-1910.
- c. Special Reports, Water Conservation Investigation, Charles, Neponset and Ipswich Rivers, Edward M. Blake, June 26, 1916, March 31, 1916, April 20, 1916.
- d. Metropolitan District Commission, Flood Control, Charles River and Mother Brook, Chapter 768, Acts of 1955, Howard M. Turner, Boston, Mass., February 17, 1956.
- e. Charles River Basin, Metropolitan District Commission, Howard M. Turner, Boston, Mass., March 13, 1957.
- f. A Preliminary Planning Study, the Banks of the Charles River, Metropolitan District Commission, Charles W. Eliot, Landscape Architect, February 1961.
- g. Hydraulic Study of the Proposed Relocation of Muddy River in-closed conduits, Interstate Route 695, City of Boston, The Clarkeson Engineering Company, Inc., Wellesley, Massachusetts, for Department of Public Works, Commonwealth of Massachusetts.

h. The August 19, 1955 hurricane-storm caused extensive flood losses and serious disruption in built-up areas along the Charles River Basin, particularly in Boston and Cambridge. The Metropolitan District Commission engaged consulting engineers to study the problems and present solutions. The studies and findings were presented in a series of ten reports from 1956 through 1959.

GENERAL PHYSICAL DESCRIPTION

7. LOCATION AND EXTENT

The Charles River Watershed, covering some 307 square miles, is located in eastern Massachusetts and is bordered, counter-clockwise from the north, by the watersheds of the Mystic, Merrimack, Blackstone, Taunton and Neponset Rivers. It contains all or portions of 5 cities and 30 towns including important and highly developed portions of Metropolitan Boston and less developed but rapidly growing suburban and rural areas (see Plate No. 1). An impoundment formed by the Charles River dam located 1.2 miles above the mouth of the river is known locally as the "Charles River Basin." To avoid confusion, the entire area draining to the Charles River will be referred to throughout the remainder of this report as the "Charles River Watershed."

a. Report Area. The report area covers the drainage of the 12.6 miles of the Charles River which flows in a general easterly direction from the Moody Street Dam in Waltham to the river's mouth at Boston Inner Harbor (see Plate No. 2). In the upper 2.8 miles of this reach, above the upper limit of the Charles River Basin are the pools created by the Bleachery Dam, crest elevation 20.6 feet, msl, in Waltham, and the Watertown Dam, crest elevation 8.6 feet, msl, in Watertown. (See Plate No. 3.) The 58-square mile drainage area of the lower 12.6 miles of the Charles River embraces large parts of Boston, Brookline, Newton, Waltham, Watertown, and Cambridge, and lesser parts of Lexington, Belmont, Arlington and Somerville.

Most of the watershed of the Lower Charles River is densely developed. At the present time, there is little open land in private ownership available for new building development. Most existing open land is specifically reserved for public and semi-public use. Although the area is essentially built-up, it is subject to further intensification of land use and water demand by further building and rebuilding. Such rebuilding was under way on an important scale in parts of Boston and Brookline in 1967 and is presently being planned for areas in Cambridge, Somerville and Waltham. More than \$155 million in Federal financial aid is scheduled

for urban renewal in the watershed - of which \$122 million is in Boston alone. There are \$150 million or more additional federal aid commitments for sewers and water mains, for improvements in metropolitan rapid transit service and for other federal aids in the report area.

b. Charles River Basin. The River below Watertown Dam, prior to 1910, was a tidal estuary. In 1910, after almost forty years of public agitation and ten years of study and engineering, the Charles River Dam at Leverett Street, Boston, was completed, creating the Charles River Basin, a landscaped, reflecting pool modeled on the Alster River Basin, Hamburg, Germany.

The Basin, occupying 8.6 river miles above the Charles River Dam, is the major water feature of the study area. The Basin is about 675 acres at its design water surface level of 2.38 feet, msl. A principal portion of the Basin downstream of the Boston University Bridge has a length of 2.6 miles and widths varying from 300 to 2,000 feet; the latter width prevails throughout the central 1.5 miles of this reach.

8. TRIBUTARY STREAMS

In the report section of the lower Charles River, there are ten principal tributary streams, six of which have been inclosed in conduits. In terms of drainage area, the two more important are (1) Beaver Brook which drains 11.2 square miles in the northwesterly portion of the Lower Charles River Watershed and (2) Muddy River, the Back Bay Fens, and Stony Brook (Conduit) which together drain 21.1 square miles in the southeasterly part of the watershed. Thus, these two tributaries drain approximately 55 percent of the total run-off area of the Lower Charles River. Each is further described below.

a. Beaver Brook. This brook rises in a swampy area at an elevation of nearly 210 feet, msl, in the southeastern part of Lexington. From its source it flows generally southeast about 2.6 miles through Lexington and Arlington, then along the Waltham-Belmont town line about 1.3 miles, and then turns and runs westerly about 1.9 miles to its mouth at the Charles River, about 0.5 mile below the Moody Street Dam. Along the last mile of its length it is inclosed in a conduit. The Brook has a total length of about 5.8 miles, a fall of nearly 190 feet, and, together with its two principal tributaries, Clematis and Chester Brooks, drains an area of some 11.2 square miles.

b. Muddy River, the Back Bay Fens, and Stony Brook (Conduit). Muddy River rises in Jamaica Pond, in the west central part of Boston, at an elevation of approximately 60.0 feet, msl, and flows northerly



STORROW INTERCHANGE AND BACK BAY FENS
BOSTON FINE ARTS MUSEUM, UPPER RIGHT
(26 MARCH 1968)

about two miles through a series of small ponds, conduits, landscaped pools, and channels to its former mouth and natural entry into the Back Bay Fens at Park Drive. At this location, it drains an area of about 6.1 square miles. In the first 0.8 mile below Jamaica Pond, this stream drops about 56.3 feet, to an elevation of approximately 3.7 feet, msl. In its remaining 1.2 miles of length it flows at a nearly constant level of 3.0 feet, msl. The dry weather flow of Muddy River continues northerly about 0.8 mile in a conduit under Brookline Avenue and Deerfield Street, and enters the Charles River Basin at a point about 1.9 miles above the Charles River Dam.

The Back Bay Fens today is a series of conduits and open channels, with landscaped banks, following in general the old course of Muddy River through the Back Bay (formerly a Charles River tidal estuary) for a distance of about 1.2 miles. Fens flows continue nearly 0.4 mile farther, mainly through conduits and under numerous bridges, to the Charles River Basin at a point 500 feet upstream of the Harvard (Massachusetts Avenue) Bridge and about 0.25 mile downstream of the outlet of the Muddy River conduit at Deerfield Street. The Fens, in the backwater of the Charles River Basin, has a local drainage area of 1.1 square miles. Storm flows from Muddy River enter the Fens at a point about one mile above its outlet at the Basin.

In addition, the Fens receives storm overflows from the Stony Brook Conduit. This conduit, 7.8 miles in length, follows the old course of Stony Brook, and has a drainage area of 13.9 square miles. The Brook rises in Turtle Pond in Stony Brook Reservation at 131 ft., msl, in the southern part of Boston, and flows in a general northerly direction. Except for one mile in the Reservation, the brook is now enclosed in a conduit. All of the dry-weather flow and a part of the storm flow in Stony Brook Conduit are now discharged into the Boston Marginal Conduit which follows the south bank of the Basin and empties into the tidal portion of the Charles River, downstream of the Charles River Dam.

9. TOPOGRAPHY

Prior to construction of the Charles River Dam in 1910 the Lower Charles River was a tidal estuary that extended upstream nearly ten miles. Even before construction of the dam, extensive land-fill alterations had modified the shoreline of the estuary. One of the major modifications accomplished in the middle 19th century, was the filling of some 750 acres of former tidal marsh, locally known as Back Bay, extending about one and one-half miles along the south shore of the river. In addition, nearly 150 acres of former marsh along the north or Cambridge shore have been filled as well as approximately 500 acres of marsh

located along both banks for nearly six miles along the upper end of the estuary. Periodic changes in the shoreline of the Lower Charles River are shown on Plates B-1 through B-3, Appendix B.

Except for interior and perimeter hills, the terrain of the study area is mainly flat to gently rolling. In an area extending upstream about six miles above the river's mouth and back about one mile from both banks, in Boston and Cambridge, ground elevations range from below 10 to some 50 feet above mean sea level. Perimeter hills along the southern limits of the watershed in Boston reach elevations ranging from about 120 to 250 feet, msl. In Brookline and Newton, on the south side of the river, elevations of 50 to 150 feet prevail with several hills reaching elevations of 220 to 280 feet.

On the north side of the river, elevations ranging from about 50 to 300 feet prevail in the upland areas in Watertown, Waltham, Lexington, Belmont and Arlington with many hills at elevations of 260 to 370 feet or more. In the lowland areas of Watertown and Waltham, close to the river, elevations of 20 to 100 feet prevail.

Notable heights in the watershed of the Lower Charles River include Prospect Hill in Waltham which, with an elevation of 478 feet, msl, is the highest point in the study area; Breeds Hill in Charlestown with an elevation of 82 feet, msl, at the base of Bunker Hill Monument; and Beacon Hill in Boston with an elevation of 103 feet, msl, at the northwest end of the State Capitol Building.

10. GENERAL GEOLOGY

The Charles River is a perfectly normal consequent stream. It has a fall of about 350 feet and a well-developed meander pattern having an average amplitude of about four miles and an average frequency of about six miles. The stream traverses approximately 80 miles in covering a straight line distance less than 30 miles. The course of the Charles River is governed only in a very broad sense by the underlying rocks. The rock-fault basin of Boston is a basic reason for the stream flowing northeasterly. The short length of the river is attributed also in a very general way to the nature of the surrounding hardrock territory which is an eroded surface essentially planed off. The irregular old hardrock surface, its depressions glutted with glacial debris, is not conducive to the development of long, free-flowing streams.

The Charles River lies mostly on unconsolidated glacio-marine and outwash sediments, with only its upper reaches on the more resistant glacial till and bedrock upland. Surficial materials have influenced

the course of the river with resistant till and rock hills serving as points of deflection which have influenced the development of meanders.

The principal mineral resources of the watershed are sand, gravel, and stone for aggregate. These resources are not seen to play an important role in the future economic development of the watershed area since the most accessible deposits have been largely depleted and are giving way to urban sprawl. Construction materials are being imported into the Boston area from sources as remote as New Hampshire.

11. AREA MAPS

The Charles River and its watershed are shown on standard quadrangle sheets of the U.S. Geological Survey at a scale of 1:24,000. Plate 1 of this report is a map of the entire watershed of the Charles River and Plate 2 is a map of the watershed of the Lower Charles.

GENERAL ECONOMIC CHARACTERISTICS

12. GENERAL

The Charles River Watershed is geographically and economically a part of the largest employment and population cluster in New England. This cluster is the northern terminus of "megalopolis", the Atlantic coastal urban strip between Washington and Boston in which live about 44 million people, nearly one-fifth of the United States population. The Lower Charles report area contains approximately one-fifth of the total watershed of the Charles River, and averages four times as many residents per square mile as the area next upstream. The population of the report area of the Lower Charles River in 1965 was about 593,700 above Warren Avenue, Boston, or about 70 percent of the total watershed population. In addition to its resident population, the day-time occupancy of the area is nearly three times the number of permanent residents by reason of commuters, shoppers, students, tourists and others.

Located in the report area are the principal governmental, educational, medical, financial, and insurance institutions of New England. The cultural assets, universities, historic structures, and museum and library treasures found in this area are of national and international importance.

In the Lower Charles Report area are located approximately 95 percent of all the jobs in the entire Charles River watershed that were covered by Federal employment security provisions in 1965.

13. URBAN DEVELOPMENT

The watershed of the Lower Charles River was initially settled within the first eight years after the 1629 arrival of the Massachusetts Bay Company. Six communities were established in those eight years, which have since become ten municipalities. Land-filling alteration of the Charles River coves and shores of the Boston peninsula began in 1643. Further Charles River alterations were voted in Boston in 1794, 1804 and 1814; and in Cambridge at other dates during that general period of time.

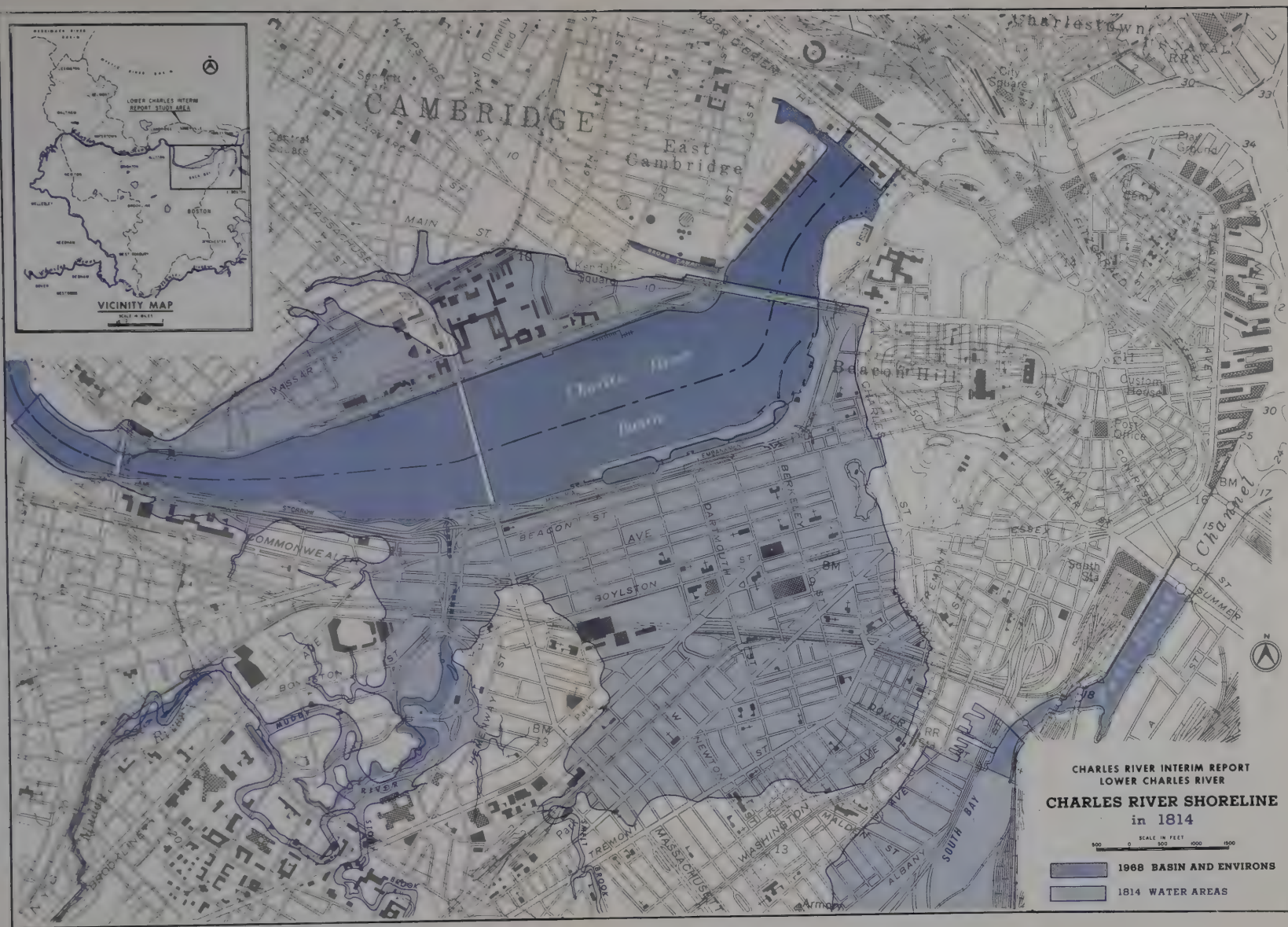
The most extensive single alteration in the configuration of the Lower Charles River shoreline was the impoundment in 1821 of the Back Bay by the Roxbury Mill Dam along an alignment that is now Beacon Street. Filling of this impoundment over a period of 50 years, accelerated by railroad building in 1831-34, resulted in making more than 750 acres of new land available on the south shore of Charles River.

In addition, more than 650 other acres of Charles River marshes and shallows have become filled and put to urban land uses between Warren Avenue, Boston, and Moody Street, Waltham.

14. POPULATION

The 1965 population resident in the Lower Charles River watershed above Warren Avenue, Boston, is estimated at 593,700. This population is located in and distributed among the watershed parts of ten cities and towns. Approximately 50 percent of the resident lower Charles population was in watershed Boston, as follows:

<u>City or Town</u>	<u>Total Population</u>	<u>Estimated Population in Report Area</u>
Arlington	52,480	3,000
Belmont	28,795	11,350
Boston	616,325	298,950
Brookline	53,610	49,050
Cambridge	92,675	67,350
Lexington	31,390	3,900
Newton	88,515	57,400
Somerville	86,330	28,350
Waltham	57,135	38,100
Watertown	<u>40,115</u>	<u>36,250</u>
	1,147,370	593,700



This population pattern has resulted from 330 years of urban growth, spreading from multiple early nuclei of settlement. During the first 45 years of colonization, twelve settlements (six lower, plus six middle and upper Charles) appropriated 75 miles of the 80 mile total length of the river.

Despite twenty-fold increases in numbers of people over the last 200 years, the concentration of residents in the Lower Charles as a proportion of the entire Charles watershed population is strikingly illustrated in the following figures estimated from state census:

<u>Year</u>	<u>Entire Charles R.</u>	<u>Lower Charles R.</u>	<u>Percent</u>
1765	33,700	22,700	67
1865	207,700	168,500	81
1965	847,500	593,700	70

It has been estimated by the Regional Economics Division, Office of Business Economics, U. S. Department of Commerce, that the Charles River watershed will share in the future population growth of the U.S. Atlantic seaboard, currently projected at some 50 percent by the year 2,000. If so, the population in the watershed of the Lower Charles River can be expected to reach 890,000 by the end of the next 32 years.

15. INDUSTRY

Manufacturing is of considerable importance to the economy of the cities and towns in the watershed of the Lower Charles River. The area is a center of industrial employment in Massachusetts and New England. Nearly one-fifth of all the jobs in manufacture in Massachusetts as reported by the Massachusetts Division of Employment Security in September 1965 were in the study area of the Lower Charles River -- approximately 143,000 in Lower Charles River municipalities compared with 664,500 in the state. A wide variety of items are produced at the many manufacturing plants in the report area. Among the 50 largest concerns in the state, measured in terms of number of employers, are the following seven with plants in the area: General Electric Company, Western Electric Company, B. F. Goodrich Company, Polaroid Corporation, United-Carr Inc. (Fastener Division), American Biltrite Rubber Company, and Green Shoe Manufacturing Company.

16. COMMERCE AND OTHER ACTIVITIES

The area of the Lower Charles River is an important center of commerce, finance and trade. Numerous retail and wholesale outlets,

insurance companies, and financial establishments are located here. The concentration of such activities is indicated by the fact that over 40 percent of all the reported jobs in Massachusetts under the categories of retail and wholesale trade, finance, insurance, and real estate are in the study area -- 224,000 out of a total of 523,000 for the entire state.

Also of important consequence to the economy of New England are the concentrations of hospitals, other medical facilities, and institutions of higher learning that are found in the area. In the Lower Charles River portions of Cambridge and Boston, in 1966, were located 42 out of a total of 105 degree-granting, educational institutions in Massachusetts. These 42 institutions, in September 1966, enrolled a total of 110,600 students and employed 9,100 administrative and faculty personnel. Also, out of a total of 53 general hospitals listed in Greater Boston in 1967, there are 29 in the Lower Charles River area with a reported aggregate of 7,479 beds, and staffs totaling over 19,300.

In addition, of considerable economic impact is the number employed within the report area in all levels of government. In 1965, some 278,000 were so employed in the state, at Federal, state, county and municipal levels. It is estimated that one-third or more of this number are government employed at locations in the report area of the Lower Charles River.

17. TRANSPORTATION

As may be anticipated, the area of the Lower Charles River and its environs, is served by all modern means of transportation. Boston, the capital of Massachusetts, is a New England transportation gateway to the rest of the United States lying to the south and west.

Feeding into the area are a number of major U.S. and state highways including U.S. Route 1 running north and south, U.S. Route 3 running northwest, and U.S. Route 20 and State Route 9 running to the west. A section of the Massachusetts Turnpike, Interstate 90, traverses the watershed of the Lower Charles River. A section of Interstate Highway I-95 will traverse the watershed. A proposed "Inner Belt" (I-695) expressway around the center of Boston, would cross the Charles River just below the Boston University Bridge, about 3.9 miles above the mouth of the river. Metropolitan District Commission motorways in park lands border most of both banks of the lower Charles River.



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FOR THE MUSEUM OF SCIENCE

CHARLES RIVER DAM
LOOKING TOWARD LOGAN AIRPORT AND BOSTON HARBOR

Railroad services are provided by the Boston and Maine Railroad, the Boston and Albany Railroad, the New York Central System, and the New Haven Railroad, now parts of the Penn. Central system. Regularly scheduled airline service, freight and passenger, both local and world-wide is afforded by a number of major airlines operating out of Logan International Airport in Boston, about two miles east of the mouth of the Charles River. Rapid transit and bus service in Boston and between Boston and the surrounding communities is furnished by the Massachusetts Bay Transportation Authority.

Water transportation in the lower Charles is aided by an existing Federal navigation project of 35-foot depth (see paragraph 33) which connects with the major ship channels constructed and maintained in Boston Harbor by the Federal government.

18. WATER SUPPLY & SEWERAGE

The water division of the Metropolitan District Commission supplies water in nine of the ten municipalities in the Lower Charles Report Area, and supplies water as needed in the tenth community, Cambridge. That city has its own 23.6 square mile water supply area, and reservoir system outside but bordering the Lower Charles Report Area on the west. The MDC supply source is outside the Charles River watershed.

The sewer division of the Metropolitan District Commission now collects, treats and disposes of all dry-weather sewage flows from all the ten municipalities wholly or partly in the Lower Charles Report Area. In times of high rainfall, combined sewers in the older Lower Charles municipalities, (principally Boston, Brookline, Cambridge, Newton and Watertown) may overflow through relief ports into the Lower Charles. Some 42 relief port locations have been identified, (see Appendix H). The MDC has under construction extensive Charles River sewage overflow elimination measures. All Lower Charles sewage is conveyed, treated and disposed of by MDC in outer Boston Harbor.

CLIMATOLOGY

19. GENERAL

The Lower Charles River watershed has a variable climate characterized by frequent and usually short periods of precipitation. The area lies in the path of the "prevailing westerlies" and the cyclonic weather disturbances that cross the continent from the west or southwest. It is also exposed to occasional coastal storms, some of tropical

origin, which travel up the Atlantic seaboard and through or near the New England states. In the late summer and autumn months, these storms occasionally attain hurricane intensity. Detailed information and statistics pertaining to the climatology of the area are given in Appendix D.

20. TEMPERATURE

The average annual temperature of the Lower Charles River watershed is about 50°Fahrenheit. The yearly range of mean monthly temperature is wide; ranging between 67° and 72° F. in July and August and between 25 ° and 29° F. in January and February. Temperature extremes range between occasional highs slightly in excess of 100°F. and occasional lows below minus 20°F.

21. PRECIPITATION

The average annual precipitation over the Lower Charles River watershed is about 43 inches, distributed rather uniformly throughout the year. At any one station, the range between maximum and minimum values of average monthly rainfall is only about one inch. The annual snowfall over the immediate area varies from about 42 inches at Boston on the coast to 60 inches at the Blue Hill Observatory, at 640 feet, msl, about nine miles south of Boston. Snow cover reaches a maximum depth in early March with the water content in early spring often exceeding two inches.

22. STORMS

The rapidly moving cyclonic storms or "lows" that move into New England from the west or southwest produce frequent periods of unsettled but not extremely severe weather. The worst storms have often been those of tropical origin which travel up the Atlantic coast and move over or within striking distance of New England. They occur generally during late summer and early autumn. Four notable recent storms in the Charles River watershed occurred in March 1936, July 1938, August 1955, and March 1968. The hurricane "Diane" storm of August 1955 produced floods and damage throughout much of southern and eastern New England. The accompanying rains fell on ground previously saturated by rainfall from hurricane "Connie" which occurred one week earlier. Rainfall in the period August 17th - 20th, 1955, ranged between 10 and 13 inches over the Lower Charles watershed.

STREAMFLOW DATA

23. The U.S. Geological Survey maintains and publishes records of three stream gaging stations in the Charles River watershed. One is located near Moody Street in Waltham, at the upper end of the report area; the other two are approximately 7.5 and 21.5 river miles further upstream. Records of the Moody Street gage indicate a mean flow at this location of 368 cfs for the period 1931-1966, and a maximum flow of 2,620 cfs on 22 March 1968. These flows reflect the diversion of a portion of the Charles River flow to the Neponset River by way of Mother Brook in Dedham, about 14 river miles above Moody Street. Further data on streamflow is contained in Appendix D.

TIDE DATA

24. The mean range of tide in Boston Harbor, at the mouth of the Charles River, is 9.5 feet, from mean low water at 4.6 feet below mean sea level to mean high water at 4.9 feet above. A high spring tide will reach an elevation of approximately 6.8 feet, msl. The highest tide of modern record is 9.3 feet, msl, which was experienced in the storm of 29 December 1959. A high of 8.9 was reached in a storm on 21 April 1940 and highs of 8.8 in storms on 30 November 1944 and 20 January 1961. Tidal heights between 8.0 and 8.6 feet, msl, have been experienced on numerous occasions during the past 35 years. Historical records back to 1723 indicate high tides reaching elevations ranging from about 9.0 to 10.1 feet, msl.

FLOODS

25. GENERAL

Outstanding floods on the Charles River may be expected in any season of the year. Early spring rains combined with melting snow resulted in the floods of March 1936 and March 1968. Heavy rains during the summer and autumn months caused flooding in July 1938, September 1954, August 1955, and October 1962.

26. FLOODS OF RECORD

Records of floods in the Charles River watershed prior to the turn of the century are meager. From all available information, the greatest such flood prior to 1900 occurred in February 1886. Other noteworthy 19th century floods occurred in 1807 and 1818. Prior to

1910, the lower 9.8 miles of the Charles River was a tidal estuary and flood experiences along this reach were of less consequence.

Four floods of major proportions have occurred on the Charles River in recent years: in March 1936, July 1938, August 1955 and March 1968. The flood of August 1955 was a major flood in all parts of the river basin. During this flood, the basin level rose 4.5 feet above normal to an elevation of 6.9 feet, msl, the highest recorded to date. A peak discharge of 3,220 cfs was recorded during this flood at the Charles River Village gaging station, 34.3 miles upstream from the mouth and a peak of 2,490 cfs at Moody Street, Waltham, 12.6 miles above the mouth. The latter flow reflects some upstream diversion of flow from the Charles River (see paragraph 23).

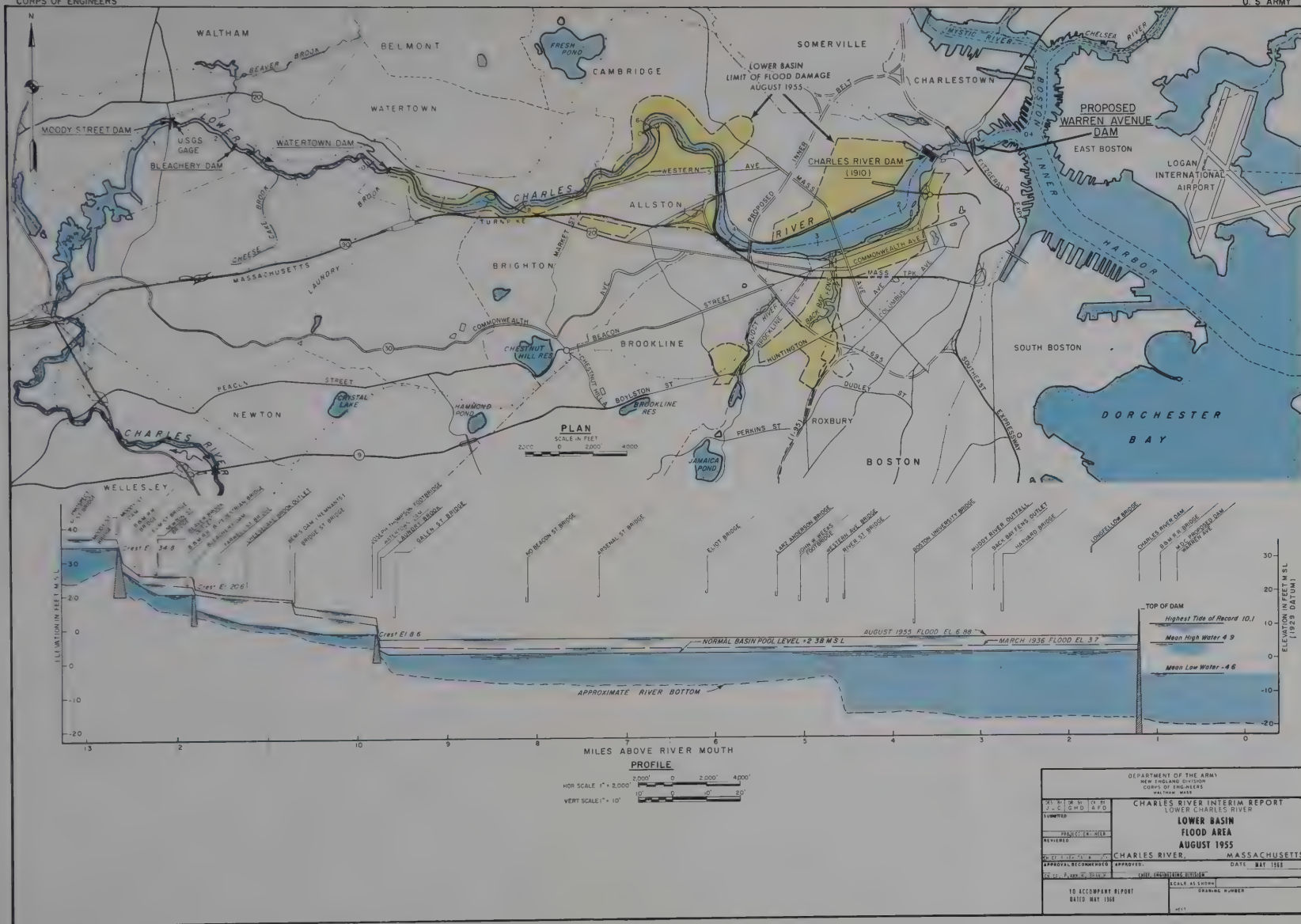
27. STANDARD PROJECT FLOOD

A standard project flood is a synthetic flood used by the Corps of Engineers to measure flood potentialities. It represents flood discharges which may be expected from a combination of severe meteorological and hydrological conditions that are considered reasonably characteristic of the region involved, excluding extremely rare combinations. The standard project flood is used as a criterion for establishing design elevations for walls and dikes in local protection projects, for determining the desirable capacity of channel improvement projects, and for checking the effectiveness of flood control reservoirs.

The standard project flood for the Lower Charles River has a peak discharge of 21,000 cfs at the existing Charles River Dam. During the record flood of August 1955, the estimated peak inflow to the Basin was 15,000 cfs of which approximately 90% was from the 58 square mile drainage area below Moody Street, Waltham.

EXTENT AND CHARACTER OF FLOODED AREA

28. Over 1,750 acres lying along both banks of the 8.6 mile-long pool or Basin above the Charles River Dam are subject to flood problems due to high water stages in the Basin. In this reach the river is the boundary between Boston and Cambridge, Boston and Watertown, and at its upper end, between Newton and Watertown. Near the lower end of the Basin, Muddy River, entering from the southwest, drains a sizable portion of the Town of Brookline, the most populous town in the County.



In Boston, the flood plain is covered by a rather complex mix of public and private institutions, private and commercial residential facilities and other commercial properties. Among the larger institutional properties involved are the Massachusetts General Hospital, Boston University, the Boston Museum of Fine Arts, and the Business Administration School of Harvard University. Lying between the built-over portion of the flood plain and the river is Storrow Drive and its westerly extension, Soldiers Field Road. This is one of the region's major traffic arteries connecting the suburbs to the west and north of Boston to the downtown area and to expressways (to the south and north-east). Also occupying the flood plain are the main line and the Beacon Park yards of the former Boston and Albany Railroad and the Boston extension of the Massachusetts Turnpike, much of which was constructed above the level of known flooding. The estimated value of properties subject to flooding in Boston exceeds \$50 million.

On the Cambridge side of the river, the lower or eastern end of the flood plain is built over with a mixture of industrial and commercial properties with some scattered obsolete residential properties interspersed therewith. The western edge of this area is adjoined by the Massachusetts Institute of Technology and research facilities which have grown up around the Institute. West of the Institute, the flood plain is occupied by commercial and residential properties, a public utility plant, the main campus of Harvard University, Mount Auburn Hospital and private school property. As in Boston, the river bank is edged by a major traffic artery, Memorial Drive, which carries Massachusetts Routes 2 and 3 to the west and north and U.S. Route 1 to the north and east. The estimated value of property subject to flooding in Cambridge exceeds \$150 million.

In Newton and Watertown, the flood plain is less intensively developed than in the cities to the east. Highways and some recreational facilities of the Metropolitan District Commission are the principal present occupants of the flood plain.

Along Muddy River in Boston and Brookline, the flood plain is occupied by commercial and residential properties, public park land and trackage of the Massachusetts Bay Transportation Authority's rapid transit line between Boston and Newton. The estimated value of property subject to flooding in this area exceeds \$9 million.

FLOOD DAMAGES

29. EXPERIENCED AND RECURRING LOSSES

Following the record flood of August 1955, the Metropolitan District Commission engaged the services of a private engineering firm to make a survey of flood losses in the Basin. The survey, which was done on a sampling basis, was carried on in late 1955 and early 1956. The survey found direct flood losses of \$800,000 for the properties investigated and by extrapolation arrived at an estimated total direct loss of \$3.6 million.

A review survey of flood losses was made by the Corps of Engineers early in 1968. Based on this survey, it is estimated that losses in a recurrence of the record flood levels of 1955 would amount to \$12.4 million under current conditions. By types, the losses would be 31.5% urban (residential, commercial and public), 25.8% industrial, 33% institutional and 9.7% highway. At a stage 2 feet higher than the 1955 stage, a level approaching the SPF, losses would amount to \$48 million.

30. ANNUAL LOSSES

Recurring losses at various stages of flooding were combined with stage frequency data to derive damage frequency as a measure of annual losses. Annual losses, so derived, amount to \$1,020,000 under conditions expected by the time of project operation.

31. TRENDS OF DEVELOPMENT

The communities bordering the Charles River Basin are under unrelenting pressure for space to house the expanding institutions and Government facilities necessary to meet the demands of a growing regional population. In addition, there is a heavy demand for industrial space, especially in Cambridge, to meet the needs of an expanding research and development industry geared to the Graduate Schools of Harvard and M.I.T. The result is certain to be an increase in the loss potential in the lower basin over time. In addition to physical changes in the flood plain, the rapid urbanization now taking place upstream of the study area combined with changes in runoff patterns occasioned by new highway construction will mean that a given flood event will become more frequent over time.



EXISTING CHARLES RIVER DAM

PHOTOGRAPH BY BRADFORD WASHBURN
FOR THE MUSEUM OF SCIENCE

32. FUTURE LOSSES

Annual losses were computed to reflect the changes in loss potential and hydraulic effects at dates in the future and discounted to an average annual equivalent value using an interest rate of $3\frac{1}{4}\%$. The average annual equivalent value of the future losses amounts to \$665,000.

EXISTING CORPS OF ENGINEERS' PROJECTS

33. The only Corps of Engineers' project in the Charles River watershed is one that provides for a mean low water depth of 35 feet in the Charles River from the Charlestown Bridge to the main ship channel in Boston Harbor, a distance of approximately 2,500 feet. The Charlestown Bridge is about 400 feet downstream of the site of the former Warren Avenue Bridge.

IMPROVEMENT BY OTHERS

34. The Charles River Dam, located about 1.2 miles above the mouth of the river, is the principal water resource improvement that has been accomplished by others in the lower portion of the watershed during this century. It was constructed by the Metropolitan District Commission (MDC), a state agency, between 1905 and 1910, for the purpose of creating a constant level pool which would eliminate tidal fluctuations, permanently cover the then unsightly and malodorous tidal marshes, and at the same time afford a pleasant landscape feature.

The dam consists of a wide earth section, retained both upstream and downstream by granite block walls, and is provided with eight sluice gates, a ten-foot wide canoe lock that is now abandoned, and a navigation lock sized to allow the passage of commercial vessels. The project was designed to maintain a pool level of 2.38 feet, msl, or 2.52 feet below the level of a mean high tide in Boston Harbor. Today, most of the earth section of the dam is occupied by the buildings and grounds of the Science Museum. (See Plate No. 4).

IMPROVEMENTS DESIRED

35. PUBLIC HEARINGS

Public hearings were held in January 1967, in Waltham, Wellesley and Franklin, to determine the views and desires of local interests. The three hearings were attended by a total of nearly 500 persons some of whom were present at two or all three of the hearings. Attending were State and local officials, representatives of other Federal agencies, members of a number of State and regional organizations and associations, representatives of local industrial and commercial interests, home owners

and other private citizens. Desires were expressed for a number of improvement measures throughout the watershed including measures for environmental preservation, flood control, pollution control, flow augmentation, recreation, conservation, and water supply. A digest of the public hearings is included as Appendix A.

36. MEETINGS WITH LOCAL INTERESTS

During the course of this study a number of meetings and conferences have been held with representatives of other Federal agencies and State and local groups including four meetings to date with the Coordinating Committee (see paragraph 4). The purposes of the meetings have been threefold: (1) to determine and clarify the desires of local interests for use or development of the water resources in the watershed, (2) to acquaint others with the progress being made on the study and the nature and extent of plans under consideration, and (3) to afford an opportunity for the exchange of views on the various aspects of the study. At these meetings, local interests have indicated the need for flood control in the lower watershed, particularly for improved control of the water level in the Charles River Basin and the control of floods in Muddy River and the Back Bay Fens. These meetings and discussions have disclosed the chief desire of local interests to be the determination of the Federal interest in a new dam for flood control and navigation at the site of the former Warren Avenue Bridge.

FLOOD PROBLEMS AND SOLUTIONS CONSIDERED

37. FLOOD PROBLEMS

There are two inter-related flood problems in the watershed of the Lower Charles River. These problems arise from the flooding of intensely developed urban areas by reason of (1) increases in the water or pool level of the Charles River Basin, and (2) overflowing of the banks of the Back Bay Fens and Muddy River owing to high flows in these tributaries and back-up from the Basin. The reduction of flood levels in the Fens area and Muddy River is largely dependent upon the control of the pool level of the Charles River Basin. These flood problems have been aggravated by the urban growth that has taken place in the immediate area. The creation of the Basin in 1910 has encouraged the construction over the past 58 years of hundreds of millions of dollars worth of construction at low elevations in Boston and Cambridge and almost all available marginal lands along the Basin have become utilized. Increased roof and pavement areas and extended storm drainage systems have speeded the peak of concentrated runoffs into the Lower Charles River and its tributaries.

a. Charles River Basin. The Charles River Dam was designed to maintain a water level in the Basin of 2.38 feet, msl, which is equivalent to an elevation 2.52 feet below mean high tide in Boston Harbor. This level is intended to be controlled by the operation of eight sluice gates in the dam. However, when the tide in the harbor is high, the gravity sluices cannot discharge water. If there is a high runoff into the Basin during times when the tide is high below the dam, the Basin may rise as much as one foot an hour. The rainfall in Hurricane "Diane" on 19 August 1955, caused the Basin level to rise some 4.5 feet above its design level and to remain at or near this level, the record level of flooding in the Basin, for about four days. An analysis of the runoff situation at this time, made by consultants for the Metropolitan District Commission and concurred in by this office, revealed that nearly 90 percent of the water contributing to the peak level of flooding in the Basin came from the area tributary to the lower 12 miles of the Charles River, below Moody Street in Waltham. The concentrations of storm water in 1955 are estimated to have begun arriving in the Basin within an hour after the start of major rainfall. The existing sluices were designed to operate under conditions of less rapid concentration - under conditions of three to four days of concentration time instead of the very short time now experienced.

Fluctuations in pool level of approximately six feet, from three feet below to three feet above design level, were contemplated at the time the dam was designed and built. Now a rise in excess of 18 inches causes overflow to adjacent low areas, the inundation of highways, and back-up through sewers and drains into the basements of buildings in the intensively developed flood plain. This situation has been experienced upon a number of occasions, in 1954, 1955, 1962 and most recently in March 1968. While the level control provided by the existing dam is inadequate, the situation would be disastrous without a dam, since tides would cause much higher flood levels (see paragraph 24)

b. Back Bay Fens and Muddy River. Flooding of lowlands in the area of the Fens and along Muddy River is caused by high flows in Muddy River, overflows from the Stony Brook conduit into the Fens, and back-water from the Charles River Basin. Flooding on the Muddy River, upstream of the Fens, is attributable in part to the inadequate capacity of the conduits at Riverway and Park Drive which conduct a part of the flow directly to the Charles River Basin and part to the Basin by way of the Fens' waterway. With the overflowing of its banks in the area upstream of the Fens, the Muddy River in 1962 subjected the tracks and tunnel of a paralleling transit line to flooding and consequent disruption of service. Flooding in the Fens, from a combination of high flows from Muddy River and from the Stony Brook drainage, is experienced by reason of a combination of inadequately sized bridge openings, conduits and channel cross

sections in the lower Fens and is particularly severe when occurring coincident with backwater from a high pool level in the Charles River Basin.

38. SOLUTIONS CONSIDERED

The primary flood problem in the watershed of the Lower Charles River, as indicated above, is the lack of control in the Basin level. No satisfactory solution to the flood problems in the Back Bay Fens and on Muddy River is possible without first achieving control of the water level in the Basin. Consideration was given to the possibilities of upstream reservoir storage, perimeter diking, diversion and the provision of pumping facilities to afford a reasonably constant level in the Basin at all times. Owing to the fact that inflow from upstream of Moody Street in Waltham contributes relatively very little to peak flooding in the Basin, the provision of storage in upstream reservoirs would be of small value in controlling Basin floods. One possibility for the diversion of flows to an adjacent watershed exists at Mother Brook. This Brook, which now diverts flows to the Neponset River, is situated about 25 miles above the mouth of the Charles River and is too far upstream to be effective in reducing peak levels in the Basin. Local protection measures would entail diking miles of riverfront and providing numerous small pumping stations to control the interior drainage. The cost for protection of this nature would exceed \$50 million. Moreover, the construction of dikes in many areas would tend to destroy the scenic values that the river localities are trying to preserve. Consideration was also given to the possibilities of using a combination of flood-proofing and zoning measures to decrease future flood damages in the area adjacent to the Basin. It was determined that such measures would be impossible of achievement except through the expenditure of great sums of money and through the complete disruption of city functions. This alternative was therefore abandoned.

a. Basin Level Control. In view of the more rapid filling of the Basin that is being experienced today following heavy rainfalls, control of the water level in the Basin through the provision of a pumping station becomes the one positive and economically feasible method of securing desired results. Five alternative locations for a pumping station at the existing dam were studied. Three utilized the existing lock as a discharge channel, and one required the installation of a discharge conduit through the existing dam, near the middle of the dam. The fifth used the existing lock as an entrance channel to the pumping station located downstream of the lock. This proposal required an extension to the lock and installation of a new lock gate. These five plans were either physically or financially not feasible owing to unusually difficult and costly foundation conditions, undesirable hydraulic characteristics, and other problems such as the interruption of navigation during the con-



PHOTOGRAPH BY BRADFORD WASHBURN FOR THE MUSEUM OF SCIENCE.

LOWER CHARLES RIVER

struction period. Further, they would not provide for existing and future navigation needs. The five considered plans are shown on Plate No. 5.

Consideration was next given to the possibilities of providing a pumping station in connection with a new dam to be located about 2,250 feet downstream of the present Charles River Dam. The site is at the abandoned Warren Avenue highway bridge between Boston and Charlestown and is just upstream of the present Charlestown Bridge. This project, including provisions for navigation locks, a fish ladder, and a highway viaduct, would secure complete control of the water level in the Charles River Basin. (See Plate No. 6). The plan, formulated by consultants for the M.D.C., is described in paragraph 41 below.

b. Muddy River and Back Bay Fens. A new highway facility, the Inner Belt Expressway, Route I-695, may traverse approximately 3,000 linear feet of the Fens at and below the Muddy River conduit at Park Drive. This new expressway, if and when constructed, would cross two Stony Brook conduits and Muddy River conduit at Park Drive, and in effect, dam Muddy River at this location where it enters the Fens (see Plate No. 7).

Design of the new expressway provides for two Stony Brook siphons under the highway to maintain present flow conditions. No provisions have yet been advanced for the handling of flood flows from Muddy River. One method would be to construct a siphon under the future Inner Belt to assure the continuance of a flow, of 300 to 400 cfs, from Muddy River to the Charles River Basin by way of the existing Brookline Avenue/Deerfield Street conduit, and the continuance of remaining flows, in excess of 400 cfs, through the Fens to the Basin. However, since the waterway openings in the Fens area are presently inadequate to accommodate the combined flood flow contributions from Stony Brook and Muddy River, significant enlargement of these openings is necessary, if overbank flooding is to be prevented. Improvement of this nature would require extensive and costly construction.

An alternative solution would be to divert the flood flows of the Muddy River directly to the Charles River Basin by means of a new conduit constructed as part of the new Inner Belt. The U.S. Bureau of Public Roads has proposed that this alternative be explored by the Massachusetts Department of Public Works. Should such a conduit be built as part of the Inner Belt, the flood flows reaching the Fens would be limited to the Stony Brook contributions and only rather minor alterations in waterway openings would suffice to pass future flood flows.

NAVIGATION PROBLEM AND SOLUTION CONSIDERED

39. NAVIGATION PROBLEM

The existing single lock at the Charles River Dam is not adequate for handling the ever-increasing recreational boat traffic and commercial vessel traffic to and from the Charles River Basin without congestion and long delays. The existing locking facilities were completed in 1910 for the increasing commercial traffic and the nominal pleasure craft usage at that time. This trend continued until 1926 when a peak of 7,505 lock passages were made by commercial vessels and approximately 1,400 trips by recreational craft. Since that time, there has been a rapid growth in the numbers of pleasure boats and a gradual decline in commercial vessels using the lock. 576 passages were made through the lock by commercial vessels in 1967 (excluding the months of October and November when the lock was closed for repairs) while the number of recreational boat passages was nearly 13,000 in those ten months.

The navigation lock is 45 feet wide and 350 feet long. The sill elevations provide water depth of 18 feet at low water conditions. The lock is equipped with two gates which move horizontally into place from slots in the east wall of the lock. These gates by present-day standards are obsolete and inadequate. Further, the lock has proved insufficient to accommodate recreational boat traffic during peak summer days. Present navigation difficulties will become more pronounced as a result of nominal increase in commercial vessel traffic and rapid and substantial increase in recreational boating expected in future years. While commercial traffic in the basin has been declining for many years, it is now believed to have essentially stabilized. The present traffic involves deliveries of heavy fuel oil to the gas and electric generating facility located on the Broad Canal, Cambridge, about one-half mile above the existing dam. This facility was rebuilt at this location in 1949 and is expected to remain here throughout the navigation project life. Company officials state that oil receipts will probably increase on an average of one to two percent per year. Large deliveries of oil are also made to the terminal facilities of a major oil company on Lechmere Canal in Cambridge, next to the present dam. Receipts of this company are also anticipated to increase at an average one to two percent each year.



EXISTING NAVIGATION LOCK LOOKING DOWNSTREAM AT
LOWER LOCK GATE UNDER REPAIR

Conditions conducive to pleasure boating are expected to improve by reason of (1) a reduction in sewage pollution resulting from the Metropolitan District Commission comprehensive pollution control program, (2) conservation of water surface through the construction of new marinas with individual slips rather than the mooring of boats in open water, (3) new regulations regarding the use of the Basin by boats and (4) expanded and improved locking facilities.

The continuing trend toward greater boating activity is expected to result in a substantial increase in the number of pleasure boats in the Basin. At present, there are some 1,000 power boats based in the Basin, including an equivalent transient trailer fleet of 100 or more boats, which use the lock. It is estimated that this number will expand to 2,550 boats along an accelerated growth curve, during the next fifty years.

40. SOLUTIONS

It is considered that the optimum plan for alleviating the existing and prospective navigation difficulties would be to abandon the existing lock and provide new and larger locking facilities. The needs would be met by two small recreational boat locks, each 200 feet long and 25 feet wide; and a larger lock 300 feet long and 40 feet wide for use by commercial vessels and large recreation craft, and to supplement the small locks on peak days in the summer.

Consideration was given to improving locking facilities at the existing dam. However, the greater part of the top of the dam, comprising about 7 acres, is now occupied by the Museum of Science with an investment in facilities of about \$15 million. Because of these facilities, the sole existing lock cannot economically be enlarged and additional locks cannot economically or physically be provided. The best alternative solution is to provide adequate, efficient locking facilities at a new location for increasing commercial and recreational boat traffic. Appendix E provides the detailed analysis involved in selecting the number, type and dimensions of locks necessary.

PLAN OF IMPROVEMENT

41. GENERAL DESCRIPTION

The plan selected for controlling the water level in the Charles River Basin and improving navigation is a multiple-purpose dam across the river at Warren Avenue, downstream of the existing Charles River

dam. Upon completion of the new dam, the sluice and lock gates at the existing dam can be removed, or opened, extending the present basin water level downstream to the new dam, a distance of about 2,250 feet, some 45 acres surface area.

The new dam, of earth and concrete shown on Plate 6, will include a river pumping station with a capacity of 8,400 cfs and three navigation locks. Two of the locks, each 200 feet long by 25 feet wide, will have low water depth of 8.0 feet over the basin sill to serve the needs of recreational craft. The third lock, to accommodate commercial vessels and large recreational boats, will be 300 feet long by 40 feet wide and will have water depth of 17.0 feet over the basin sill. A fish ladder will be provided between the river pumping station and the large lock. In compliance with the requests of local interests, coordinated with the U.S. Bureau of Public Roads, the dam will be designed to support a highway viaduct to be constructed between Boston and Charlestown, over the locks and along the upstream face of the river pumping station.

42. HYDROLOGIC AND HYDRAULIC CONSIDERATIONS

The dam and other facilities including pumping plant have been designed to prevent significant flood damage under both existing and future hydrologic conditions. Any concentration of storm runoff into the Basin is estimated to begin arriving within an hour after the beginning of any major rainfall.

The tide in the river below the dam, against which inflows to the basin must be pumped to maintain the desired basin level, ranges, on the average, from 4.6 feet below to 4.9 feet above mean sea level, a mean range of 9.5 feet. A high spring tide reaches about 8.6 feet, msl, and storm tides will reach elevations ranging from about 9.3 feet to 10.1 feet, msl. The time interval for a complete tidal cycle averages about 12 hours and 25 minutes.

43. SEWERAGE MODIFICATIONS

At present, the Boston Marginal Conduit, the Cambridge Marginal Conduit, and other sewer lines empty into tidewater below the existing dam and upstream of the site of the proposed new dam. Also, a current proposal of the MDC is to construct a sewage pumping station at the outlet of the Boston Marginal Conduit to improve flow conditions in this line and prevent the overflows of combined sewage and runoff into the Basin that now occur at times of high tide. Construction of the

new dam at Warren Avenue will entail further sewerage modifications to prevent the emptying of sewage into the basin extension between the old dam and the new dam. This will be accomplished by (1) increasing the capacity of the proposed sewage pumping station at the end of the Boston Marginal Conduit; (2) constructing a pressure conduit from that pumping station to and through the new dam, and (3) installing new pipe lines to conduct the flows from the Cambridge Marginal Conduit and other sewer lines in Cambridge and Charlestown by gravity to the sewage pumping station.

44. RELOCATIONS

The multi-purpose project will necessitate the relocation of some drainage lines and power facilities at the site of the new dam.

45. REAL ESTATE REQUIREMENTS

Construction of the dam will require the acquisition in fee of about four acres of land, principally in Charlestown, and the securing of temporary easements, in Boston and Charlestown, on nearly two additional acres, a total of about six acres.

46. OPERATION OF PROJECT

The new dam will be operated primarily in the interest of flood control and navigation. The fish and wildlife resources of the basin will be enhanced by the provision of a fish ladder in the dam. Pollution abatement benefits will be realized by a planned method for operation of the locks. At times of moderate rainfall and when the harbor tide is below the basin design water level, the basin level will be maintained at its design height by discharging water through the gated filling conduits along the sides of each lock. When the harbor tide is higher than the basin level, also at times of major flooding, inflows to the basin will be discharged to tidewater by operating one or more of the six river pumps of 1,400 cfs capacity each.

The two small locks will be used solely by recreational craft. The large lock will accommodate the present and anticipated commercial traffic on the river consisting principally of oil barges and tugs. It will also serve the needs of other occasional traffic such as small dredges and contractor's barges and lighters. The greatest use of this third lock will be made by pleasure boats, especially on weekends during the summer months. It will be available at all times to lock the deeper draft pleasure craft that cannot enter the small locks, and it will prevent congestion at the smaller locks at times of heavy traffic. Local interests will operate the lock facilities as well as all other project features.

Lock operation during periods of high tide in the harbor will make use of lock pumps to lower the lock level down to the basin level. The pumps will draw from the lower portion of the lock, pumping into tidewater in the harbor, thereby minimizing the intrusion of salt or brackish water into the basin.

47. EFFECT OF PLAN ON OTHER INTERESTS

The plan for a new dam with pumping station and navigation locks, to control the water level in the Charles River Basin, would have no adverse effects on other interests. Construction of the project results in no curtailment of any present industrial or commercial activities. Navigation interests, both commercial and recreational, will be better served by the new locking facilities than by those now in use at the existing dam. The elimination of delays in locking between the basin and the harbor will encourage increased pleasure boating activity. Moreover, the increase in pool area provided between the two dam sites will enable the development of marina facilities in the quiet waters immediately upstream of the new dam. It will also afford a haven in times of storm to cruising pleasure boats in the Boston Harbor area.

The proposed project will tend to improve the present water quality in the river above the dam. Provisions are incorporated in the plan to prevent the entry of sewage to the basin extension between the present and the new dam. Also, the design and operation of the locks in the new dam will be such as to minimize the intrusion of salt water to the basin. The Federal Water Pollution Control Administration, Department of the Interior, have commented that the reduction of salt water intrusion would probably have a beneficial effect on the water quality of the basin. They have also commented that the plan to modify and extend all the sewage lines now discharging into the river between the existing dam and the site of the new dam is a sound suggestion. (See their letter of 1 May 1968, Appendix I).

The project will have a positive effect upon fishlife. The Fish and Wildlife Service is engaged in studies of anadromous fishery restoration on the Charles River. The results of these studies will be fully reported by the Fish and Wildlife Service before completion of the overall Charles River watershed report. The new lock and dam project, as proposed in this report, contains provisions for a fish ladder. The sizing and design of the fish ladder is preliminary, recognizing that extension of the restoration of the anadromous fishery over dams upstream of the Charles River Basin will have an impact on facilities needed at the Warren Avenue site, as also will improvement of water quality as the result of water pollution control measures. The fish ladder is considered as an incidental feature, at an estimated cost of \$10,000.

Highway transportation interests will benefit to the extent that economics are affected by designing the new dam to serve as the foundation for a highway viaduct. A needed new highway crossing at this location, without the dam project, would require the construction of either a new drawbridge or a high level highway bridge.

ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

48. FIRST COSTS

The estimated total first cost of the project is \$26.5 million. The unit prices making up this estimate are based on average bid prices in effect in January 1968 for similar work in the same general area. Property values used in the estimate reflect recent sale prices in the same general part of Boston. The costs for engineering and design, and supervision and administration are based on knowledge of the site and experience on similar projects. The estimated cost for engineering and design also reflects the fact that the Metropolitan District Commission has accomplished substantial engineering studies which will be available to the Federal government. Investment costs include interest during construction at 3.25 percent for one-half the estimated construction period of three years. A summary of first costs of the proposed project is given in Table 1.

49. ANNUAL CHARGES

Total annual charges amount to \$1,131,000. This includes interest on the total investment, its amortization over a 100-year project life, and all anticipated charges for project maintenance, operation and major replacements. The operation, maintenance and major replacement costs have been determined on the basis of a 100-year economic life for the flood control portion of the project and a 50-year economic life converted to a 100-year series for the navigation and transportation portions. A summary of the annual costs is given in Table 1. Additional data, including a breakdown of quantities and unit prices, are contained in Appendix F.

TABLE 1

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES
(January 1968 Price Level)

WARREN AVENUE MULTI-PURPOSE DAM

CHARLES RIVER BASIN, MASSACHUSETTS

<u>Project Feature</u>	<u>First Costs</u>
Lands and Damages	\$ 400,000
Relocations and Sewer Extensions	3,300,000
Dam and Appurtenant Facilities	20,500,000
Engineering and Design	800,000
Supervision and Administration	<u>1,500,000</u>
Total Project First Cost	\$ 26,500,000
	<u>Investment</u>
Interest during Construction (3 years)	\$ <u>1,300,000</u>
Total Project Investment	\$ 27,800,000
<u>Annual Charges</u>	<u>Amount</u>
Interest (3.25%)	\$ 904,000
Amortization (100 years)	38,000
Maintenance and Operation	168,000
Major Replacements	16,000
Loss of Productivity of Land	<u>5,000</u>
Total Annual Charges	\$ 1,131,000

PROJECT BENEFITS

50. GENERAL

The evaluated benefits secured from the considered plan for a dam with locks and pumping station at Warren Avenue fall into four categories and include those attributable to: (1) the prevention of flood damages, (2) increased recreational boating activity, (3) improved highway transportation, and (4) the advance replacement of an existing structure. The benefits of each nature are briefly discussed below:

51. FLOOD DAMAGE PREVENTION BENEFITS

Flood damage prevention benefits were derived as the difference between annual losses with the existing dam and no pumping station and annual losses remaining after construction of a dam with adequate pumping and sluicing capacity. Annual benefits so derived amount to \$990,000 at the time of project operation consisting of \$750,000 to prevention of damages to present development and \$240,000 for higher utilization of 800,000 square feet of basement space made possible by the project.

In addition to benefits from present development the effect of future growth and more frequent flooding in the future have been analyzed and the project is credited with the average annual equivalent value of this benefit to prevention of future losses or \$532,000. Total flood damage prevention benefits amount to \$1,522,000.

52. INCREASED RECREATIONAL BOATING BENEFITS

The new locks, with modern equipment, will afford increased locking capacity and reduced locking time. By eliminating delays, the project will encourage greater use of the locks by the present fleet of recreation boats, including trailered boats and those that will transfer to the basin, and enhance their annual recreational value by an estimated 15 percent. This value, on 1,000 boats with a total depreciated value of \$4,720,000, is estimated at \$65,000 annually.

The proposed improvement together with associated measures such as expected new launching sites and marina facilities will permit, in fact, foster a growth in the size of the local recreational fleet in the Basin. An increase of 1,550 boats, including 350 trailered boats, with a total value of \$6,655,000, appears reasonable. The benefits to this

fleet, on a "for hire" basis over a 50-year navigation economic life and making allowance for the increase in size of fleet to be anticipated even without the improvement, are estimated at \$321,000 annually.

The additional basin area created between the existing and proposed dam will provide a haven during severe storms for boats cruising in exposed areas of Boston Harbor. The benefits attributable to this refuge are estimated at \$10,000 annually.

The total annual navigation benefits, from increased recreational boating activity and additional refuge area, amount to \$396,000 annually over a 50-year period. The equivalent spread over a 100-year period for economic purposes is \$329,000.

53. IMPROVED HIGHWAY TRANSPORTATION

Provisions are included in the proposed project to design and construct the dam so that it will serve as a foundation to support a public highway bridge and to construct a highway viaduct across the dam. The benefits of this feature have been taken as the annual costs that would be incurred by a new elevated highway bridge at this location costing an estimated \$1,700,000. On the basis of a 50-year bridge life, the annual costs amount to approximately \$78,000. Converted to a 100-year series, the annual benefit becomes \$68,000 equivalent to the alternative single purpose cost.

54. ADVANCE REPLACEMENT OF EXISTING STRUCTURE

As previously mentioned, the present dam acts as a barrier to prevent tidal flooding in the basin upstream of the dam. With high tidal stages in Boston Harbor, a fortnightly occurrence, the benefits to the prevention of tidal flooding in the area above the dam exceed \$33 million annually. Assuming that the existing dam has a life expectancy of 42 years (2010) and that a new dam can be constructed at Warren Avenue, downstream of the present structure by 1978, it will extend the useful life of the present dam as a tidal barrier until 2078. The new dam can be credited with advance replacement benefits for the 65-year period from 2010 to 2078. While in theory the present annual benefit for the prevention of tidal flooding is the measure of the benefit, the analysis was based only on the cost of the construction necessary to make the dam functionally operable in 2010, or \$10 million for lockage and sluicing facility replacement.



CHARLES RIVER YACHT CLUB PIER
LOWER CHARLES RIVER BASIN
MAY 1968

The benefits realized by eliminating the cost of replacement in the year 2010 equals the annual charges (interest at 3.25% and amortization over 100 years) on the sum which at the end of 32 years would be equivalent to the then present worth of annual payments over 68 years (2010 to 2078) of the interest and amortization charges on a \$10 million construction project. This amount equals \$113,000 annually.

Construction of the new dam will obviate the need for major operation and maintenance of the existing dam, at an annual cost of \$140,000, over the 32-year period from 1978 to 2010. The benefit from this saving, over the 100-year life of the new project, equals \$93,000 annually. The remaining costs of maintenance of the land fill will reside with the users and is not a project cost.

The total benefits secured by the advance replacement of the existing Charles River Dam and creditable to the proposed new dam at Warren Avenue equals \$113,000 plus \$93,000, or \$206,000 annually.

55. SUMMARY - EVALUATED TANGIBLE BENEFITS

The total evaluated annual benefits creditable to the project, based on an economic period of 100 years, amount to \$2,125,000 and are summarized as follows:

TABLE 2

SUMMARY OF ANNUAL BENEFITS

WARREN AVENUE MULTI-PURPOSE DAM

CHARLES RIVER BASIN, MASSACHUSETTS

<u>Nature of Benefit</u>	<u>Average Annual Benefit</u>
Prevention of flood damages	\$ 1,522,000
Increased recreational boating	329,000
Improved highway transportation	68,000
Advance replacement of existing structure	<u>206,000</u>
Total	\$ 2,125,000

56. OTHER TANGIBLE BENEFITS

Construction of the project would bring employment opportunities to a sizeable segment of the Greater Boston labor force. The Boston Labor Market has a current unemployment rate of 3.4%, but there is a hard core of unemployment in the central city with an unemployment rate approaching 24%. Wages paid to members of this hard core group could be credited to the project under certain circumstances not yet applicable to Boston (redevelopment benefits). The benefit was not evaluated but it could be substantial.

57. INTANGIBLE BENEFITS

In addition to the tangible benefits attributable to the project, important intangible benefits also accrue. Disruption of the normal activities of the region's center is an event which cannot be effectively evaluated in fiscal terms but the effects are large and widespread. The dangers to health caused by polluted waters backing up into the storm drains and streets of these heavily built over areas are too serious to be permitted. Construction of the project would prevent these occurrences and other disruptive effects on community well being. Like most urban centers, Boston has a severe highway traffic problem. The additional access provided by the proposed highway viaduct will improve access to Boston from the north.

ALLOCATION OF COSTS AMONG PURPOSES

58. The costs of the recommended multiple-purpose project have been allocated to the three project purposes of flood control, navigation, and highway transportation by the separable costs - remaining benefits method. Details of the allocations are given in Appendix F. All the alternative projects used in the allocation are located at the same site as that of the Warren Avenue Dam. The alternative single-purpose project for transportation is a high-level highway bridge. The alternative single-purpose flood control project and the alternative two-purpose project for flood control and transportation are based on single lock in the new dam sized to accommodate present commercial traffic. A summary of the results of the allocation is given in Table 3 on the following page.

TABLE 3

SUMMARY OF ALLOCATION OF COSTS
WARREN AVENUE MULTI-PURPOSE DAM
CHARLES RIVER BASIN, MASSACHUSETTS
 (\$1,000)

<u>Purpose</u>		<u>First Cost</u>	<u>Investment</u>	<u>Annual Charges</u>
Flood Control	\$	18,590	\$ 19,480	\$ 734
Navigation		6,300	6,623	334
Transportation		<u>1,610</u>	<u>1,697</u>	<u>63</u>
Totals	\$	26,500	\$ 27,800	\$ 1,131

ECONOMIC JUSTIFICATION

59. The multiple-purpose dam at Warren Avenue has a benefit to cost ratio of 1.9 to 1.0. A comparison of the annual benefits of the project and its three purposes with the annual costs as determined by the separable costs-remaining benefits method of allocation is given in Table 4. As indicated in the table, inclusion of each project purpose in the multiple-purpose project is amply justified.

TABLE 4

ANNUAL COST AND BENEFIT DATA
WARREN AVENUE MULTI-PURPOSE DAM
CHARLES RIVER BASIN, MASSACHUSETTS
 (\$1,000)

<u>Purpose</u>	<u>Annual Benefit</u>	<u>Annual Cost</u>	<u>Excess of Benefits over cost</u>	<u>Benefit to Cost Ratio</u>
Flood Control	\$ 1,660	\$ 734	\$ 926	2.3
Navigation	397	334	63	1.2
Transportation	<u>68</u>	<u>63</u>	<u>5</u>	<u>1.1</u>
Totals	\$ 2,125	\$ 1,131	\$ 994	1.9

PLAN FORMULATION

60. One of the objectives of the Lower Charles study has been to investigate water resource development opportunities lending themselves to preservation and enhancement of desirable features of the urban environment. The project considered in this report fulfills that objective and proposes to replace an antiquated and obsolete lock and dam with a new dam with multiple locks, and pumping plant, which will provide a solution for the past and future growing flood problems caused by urban development. The project also will provide additional navigation facilities to meet existing and future needs and a bridge needed to improve highway transportation to and within the City of Boston. Further, at incidental cost, the project will provide a fishway, a first step in restoring migratory fish-runs.

All alternative solutions have been fully explored. These include alternate locations, sizes and numbers of navigation lock and sluicing facilities, the number of pumping plant units, and diking as structural alternatives, also flood proofing and flood zoning as non-structural alternatives.

The proposed plan of development is economically justified with a benefit to cost ratio of 1.9 to 1.0 from a national income point of view on the basis of the added benefits in excess of those deriving from the existing but obsolete facilities. If the benefits now experienced, in excess of \$33 million, were added to the net new benefits anticipated, the resulting benefit to cost ratio would be in excess of 30 to 1. This is a measure of the importance of the Charles River Dam to the urban environment.

APPORTIONMENT OF COSTS AMONG INTERESTS

61. The flood control benefits secured by the project accrue in four communities, principally to two, in the flood-prone area of the Charles River Basin.

These flood protection benefits are in the nature of local protection so that the requirements of local cooperation required by the Flood Control Act of 1936, as amended, would apply to the project costs allocated to flood control.

The navigation benefits are recreational in nature so that they are 50% general and 50% local. Sharing of costs allocated to navigation under existing policy requires that local interests provide lands and relocations, and contribute 50% of construction costs.

The transportation features have been included at local request and they will be expected to bear all costs allocated to highway transportation.

A breakdown of project costs between Federal and non-Federal interests is given in Table No. 5.

TABLE 5

COST APPORTIONMENT
(In \$1,000 at 1968 Price Level)

	<u>Federal</u>	<u>Non-Federal</u>	<u>Total</u>
<u>Flood Control</u>			
Lands and Damages	0	300	300
Relocations	0	2,420	2,420
Structures	15,870	0	15,870
Total	15,870	2,720	18,590
<u>Navigation</u>			
Lands and Damages	0	80	80
Relocations	0	720	720
Structures	2,750	2,750	5,500
Total	2,750	3,550	6,300
<u>Highway Transportation</u>			
Lands and Damages	0	20	20
Relocations	0	160	160
Structures	0	1,430	1,430
Total	0	1,610	1,610
TOTALS	18,620	7,880	26,500
<u>Summary</u>			
Lands and Damages	0	400	400
Relocations	0	3,300	3,300
Structures	18,620	4,180	22,800
Percent of Structures	81.7	18.3	100

PROPOSED LOCAL COOPERATION

62. Local interests will be required to (a) provide without cost to the United States all lands, easements, and rights-of-way necessary for construction of the project presently estimated at \$400,000; (b) accomplish without cost to the United States all modifications to existing sewerage and drainage facilities which may be required to prevent their continued emptying into the pool above the new dam presently estimated at \$3,000,000; (c) provide all relocations of buildings and utilities, highways, sewers and related special facilities that will be required by reason of construction of the project presently estimated at \$300,000; (d) hold and save the United States free from damages due to the construction works; (e) prevent encroachment on the Basin, including its new extension, which would decrease its flood storage effectiveness.

In order to assure continued and expanded recreational boating activity, local interests will be required to continue to operate and maintain existing public boat landings, open to all on equal terms, regulate the use of the basin above the dam, including the prohibiting of the discharge of pollutants into the waters of the basin, and provide public access to the new basin area between the new and the existing dam.

Local interests would also be required to provide a cash contribution of \$4,180,000, or 18.3% of the flood control, navigation and transportation structures, which represents 50% of the cost allocated to navigation structures and 100% of the cost allocated to transportation structures.

The total contribution to the project by local interests is presently estimated at \$7,880,000.

Since the project design has been predicated on planning already accomplished by the Metropolitan District Commission, the Commission should make such plans and other data available to the United States for use during the final design stage of the project. Finally, in view of the fact that operation and maintenance of the existing Charles River dam is now a responsibility of local interests, and the further fact that the new project is mainly in the nature of a local flood protection project, local interests will operate and maintain all features of the project after its completion, in accordance with regulations prescribed by the Secretary of the Army. The annual cost of such operation and maintenance,

including allowances for major replacements, is estimated at \$184,000. Local interests will also preserve all present openings - lock and sluice gates - through the existing Charles River dam in order to assure the continued flow of water and passage of boats through the dam.

COORDINATION WITH OTHER AGENCIES

63. The proposals presented in this report have been coordinated with members of the Charles River Coordinating Committee. Specifically, these have included the Federal Water Pollution Control Administration and Fish and Wildlife Service of the Department of the Interior, The Department of Health, Education and Welfare, the Department of Transportation and agencies of the Commonwealth of Massachusetts. There has been detailed consultation with the Metropolitan District Commission, a Commonwealth agency, and probable participant in providing local cooperation under laws of the Commonwealth. In addition, the plan and concept have been reviewed favorably by the Charles River Citizens Advisory Committee.

DISCUSSION

64. PROBLEMS

The principal problems under consideration in the current study of the lower reach of the Charles River are those concerned with flood control and navigation. A third, not directly associated with the other two but subject to joint consideration in the formulation of a plan of improvement, is the problem of meeting the need for improved highway transportation facilities. Other problems such as those concerned with pollution abatement and fish and wildlife enhancement are of consequence in the basin. However, they have been considered mainly to the extent of determining the degree to which they are affected by the new dam and resolving any conflict of interest. The proposal of definite measures towards the solution of these related problems is deferred for consideration in the comprehensive watershed report.

a. Flood Control. The major flood problem stems from the flooding of urban and industrial properties in the intensively developed flood-prone areas along the shores of the Charles River Basin, particularly in Boston and Cambridge. Increases in the water level of the Basin, in excess of 18 inches above the normal pool level, causes the inundation of adjacent low areas and highways and back-up through sewers and drains into the basements of numerous buildings. The problem has become particularly severe owing to the extensive urban growth that has been taking place in the area. With more intensive development and utilization of former open areas, the concentration time of

runoffs into the Basin has been greatly accelerated. The sluices in the existing Charles River dam were not designed to handle the rapid increases in volume that have been and will continue to be experienced. A recurrence of the record flood level experienced in August 1955 would today cause losses estimated at \$12.4 million, as compared to the actual loss at that time of \$5.5 million. The functional aspect of the existing dam, in preventing tidal flooding, must be retained.

b. Navigation. The single lock in the existing dam, now nearly 60 years old, does not adequately accommodate the ever-increasing traffic, especially in recreational boats, passing between the Basin and Boston Harbor. This lock was designed principally to serve the rather active commercial traffic on the river at that time, which continued until a peak was reached in 1926. Subsequently, the volume of commercial traffic decreased while traffic in recreational boats has markedly increased. Present difficulties in the nature of delays in waiting for and passing through the locks, particularly on peak summer days, will become magnified in the future as the size of the local pleasure boat fleet increases. Anticipated reductions in pollution, the construction of new marinas, the adoption of new regulations governing use of the waters in the Basin, and other factors will all foster increased boating activity and create a need and demand for improved locking facilities.

65. ALTERNATIVE SOLUTIONS

A number of alternative means of resolving the flood problem in the Basin have been considered. These include the possibilities of upstream storage, diversion of flow, perimeter diking measures, and the provision of pumping facilities. The determination that peak flooding was caused mainly by runoff from areas adjacent to the lower reach of the river rendered upstream storage and diversion of little value in reducing Basin flood levels. Local protection measures along miles of river front, with associated measures to control interior drainage, would be costly and it was determined that such measures would not afford an adequate or desirable solution to the problem. The possibilities of flood-proofing and the adoption of zoning measures were also considered but it was concluded that protection through measures of this nature could not be readily and economically achieved. The one positive method to control flood levels in the Basin, under present and anticipated future runoff conditions, is the provision of a pumping station. A number of alternative sites for a new station at and in the locale of the existing dam were

investigated. It was found that the most suitable location for a new station from engineering and economic viewpoints, would be downstream as one feature in a new dam.

Studies made of the possibilities of improving the locking facilities in the existing dam found that easing of the present navigation difficulties in this manner was not economically or physically feasible of accomplishment. Present use of the existing dam restricts the potential for increasing the present locking capacity. The best alternative proved to be one that provided modern and efficient locks in a new dam downstream of the existing dam.

66. SELECTED PLAN

The selected plan for controlling flood levels in the Basin and providing improvements for recreational boating is a multiple-purpose, earth and concrete dam across the Charles River at Warren Avenue in Boston, approximately 2,250 feet downstream of the present dam. Included in the new dam, which is designed to maintain the present normal water level, (2.38 feet, msl) within non-damage limits, are an 8,400 cfs pumping station, two small locks to serve the needs of recreational craft, and a third lock sized to accommodate present commercial vessels and large recreational boats. To meet the need for improved highway facilities in this area of the city, a highway viaduct will be constructed across the dam. A fish ladder will be provided to afford immediate access to the spawning habitat in the 11 miles of river above the dam and to permit eventual full realization of the fishery potential of the entire Charles River.

67. EFFECT ON OTHER INTERESTS

The proposed project would have no adverse effects on other interests such as pollution abatement and fish and wildlife enhancement. As a matter of fact, the project will serve to better rather than impair conditions with respect to these other interests. The new dam is the initial element in a comprehensive development program for the entire watershed of the Charles River and its construction will constitute the first step in the formulation of a program to meet the overall water resource needs of the watershed.

68. ECONOMICS

The first cost of the project, including lands, easements, and rights-of-way, modifications to sewerage and drainage facilities, and relocation of utilities, is estimated at \$26.5 million of which \$18,620,000 is the Federal share. The annual costs are estimated at

\$1,131,000, including \$184,000 for operation, maintenance, and major replacements, a responsibility of local interests.

The average annual benefits to be obtained from the improvement are estimated at \$2,125,000. This includes \$1,660,000 creditable to the purposes of flood control, \$397,000 to the purpose of navigation, and \$68,000 to highway transportation. The benefit-cost ratio of the project is 1.9 to 1.

CONCLUSIONS

69. Urban and industrial properties along the banks of the Charles River Basin, particularly in Boston and Cambridge, have sustained serious damages from flooding in the past and are faced with the continuing threat of heavy damages in future floods. In the event of a recurrence of the flood levels experienced in the record flood of August 1955, losses amounting to \$12.4 million would be experienced; with a stage two feet above the 1955 level, the losses would practically quadruple, reaching a figure of \$48 million. It is concluded that the magnitude of the potential flood losses in the flood-prone area of the Basin are sufficient to warrant the construction of a new dam, downstream of the existing dam, with pumping facilities to control the water level in the Basin, all as described in this report.

It is further concluded that the present lock in the existing dam is inadequate to meet the present and growing demands of recreational boating. Moreover, the anticipated increase in recreational boating activity in the Basin is sufficient to warrant provisions in the project of two smaller locks for recreational boats in addition to one large lock to be provided for existing vessel traffic, including commercial. Also, a need exists for a new highway crossing of the Charles River in the Warren Avenue area of Boston and Charlestown and this can be effectively and economically met by including a highway viaduct in the design and construction of the new dam.

In summary, it is concluded that a new dam, with additional navigation locks, a fishway, and with a pumping station, and a highway viaduct overhead, presents the best engineering and economic solution to the need to preserve and enhance the unique urban environment created by the Lower Charles River Basin and to solve existing flood control, navigation and transportation problems.

The proposed project, with an estimated first cost of \$26.5 million, has a benefit-to-cost ratio of 1.9 to 1.0.

RECOMMENDATIONS

70. The Division Engineer recommends that Federal construction of a dam at the Warren Avenue site on the Charles River, Boston, Massachusetts, be authorized for the purposes of flood control, navigation, and highway transportation, essentially as described in this report, and with such modifications thereof as, in the discretion of the Chief of Engineers, may be advisable. The presently estimated first cost of the project is \$26,500,000, of which the estimated Federal first cost is \$18,620,000, and the non-Federal cost is \$7,880,000.

He further recommends that the project be authorized subject to the condition that local interests, prior to construction, furnish assurances satisfactory to the Secretary of the Army that they will:

- a. Provide without cost to the United States all lands, easements, and rights-of-way necessary for construction of this project, presently estimated at \$400,000;
- b. Provide, without cost to the United States, alterations and relocations to existing sewerage and drainage facilities which may be required to prevent their discharge into the pool above the dam, presently estimated at \$3,000,000;
- c. Provide, without cost to the United States, all alterations and relocations of building, utilities, highways and other facilities made necessary by reason of construction of the project, presently estimated at \$300,000;
- d. Hold and save the United States free from damages due to the construction works, or changes to water rights;
- e. Prevent any encroachment on the Basin, including the extension between the existing and new dam, which would decrease its flood storage effectiveness;
- f. Continue to operate and maintain existing public use, access, and landing facilities for recreational boats, open to all on equal terms;
- g. Provide public access to the new area of the Basin between the new and existing dams, open to all on equal terms;

h. Regulate the use, growth and development of navigation and navigation facilities in the Basin with the understanding that they will be open to all on equal terms;

i. Establish regulations prohibiting discharge of untreated sewage, garbage and other pollutants in the waters of the Basin by users thereof, which regulations shall be in accordance with applicable laws and regulations of Federal, state and local authorities responsible for pollution prevention control;

j. Preserve present openings--locks and sluices--through the existing Charles River dam in order to assure the continued flow of water and passage of boats through the dam;

k. Bear 18.3 percent of the total first cost of the structural features of the project, a sum presently estimated at \$4,180,000, which represents 50 percent of the cost of structural features allocated to navigation and 100 percent of the cost of structural features allocated to highway transportation; provided that such contribution may be paid either in a lump sum prior to commencement of construction or in installments prior to commencement of pertinent items, in accordance with construction schedules as required by the Chief of Engineers;

l. Operate and maintain all features of the project after its completion in accordance with regulations prescribed by the Secretary of the Army, at an estimated annual cost of \$184,000, including allowances for major replacements;

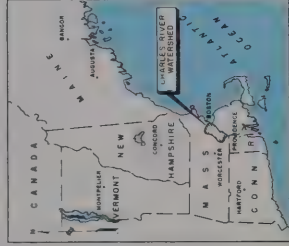
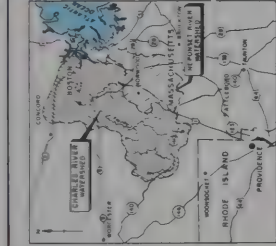
m. Furnish to the United States, without cost, all available engineering data pertinent to the project including plans prepared for the Metropolitan District Commission for construction of a dam at Warren Avenue.

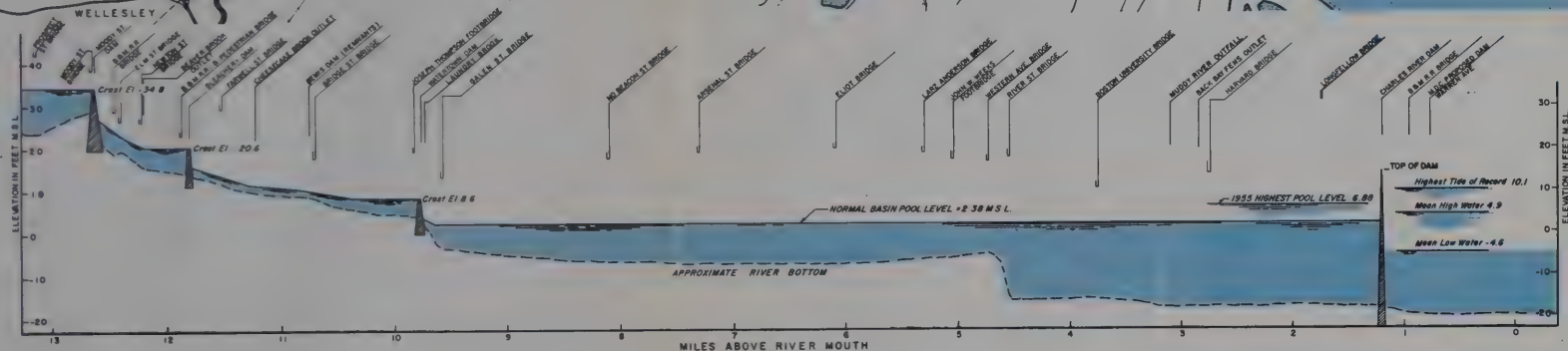
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1. Attachment I
2. Appendices A thru I

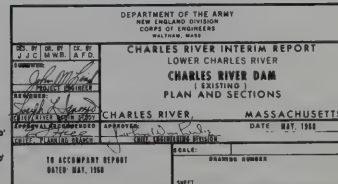
REMI O. RENIER
Colonel, Corps of Engineers
Division Engineer

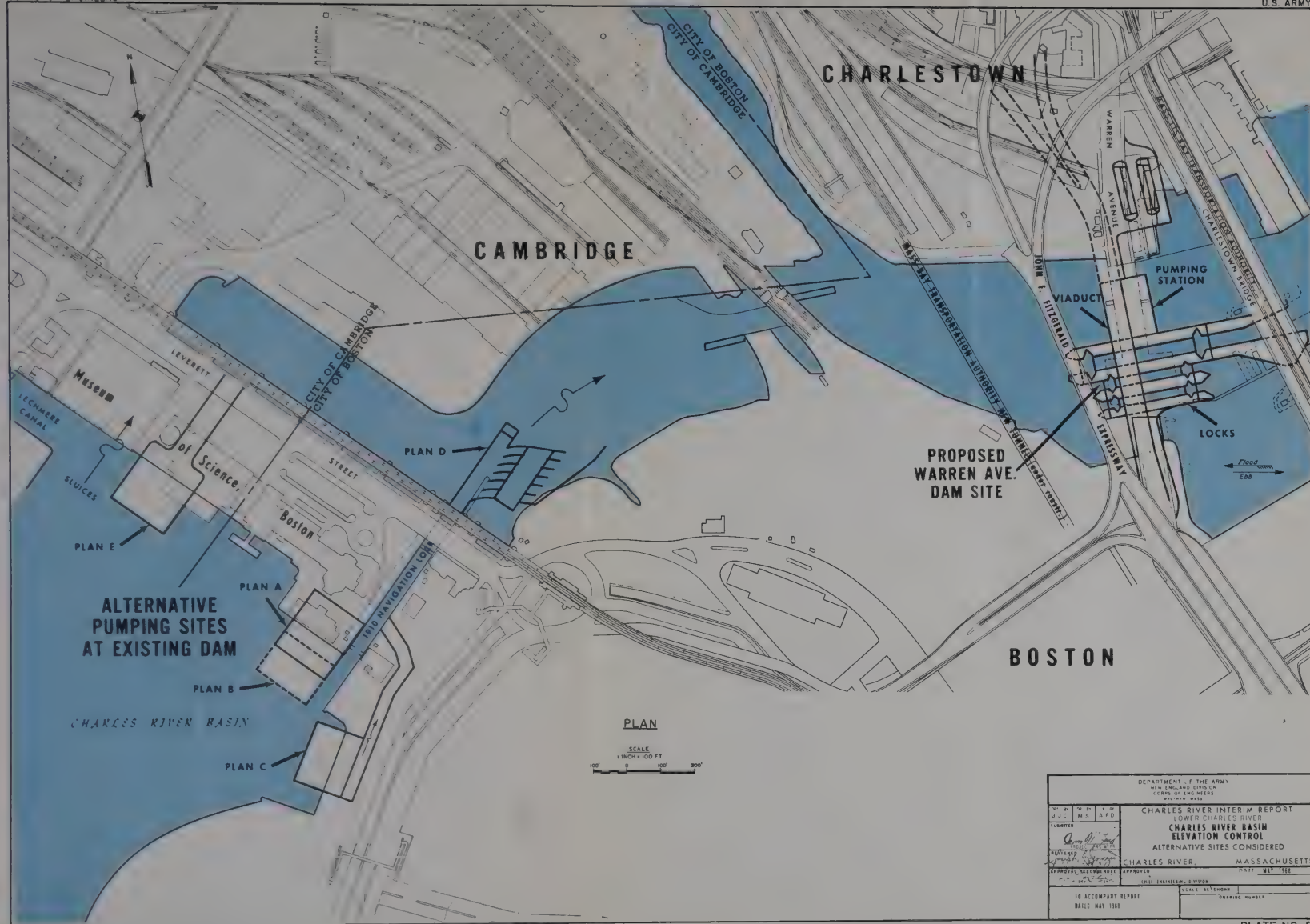
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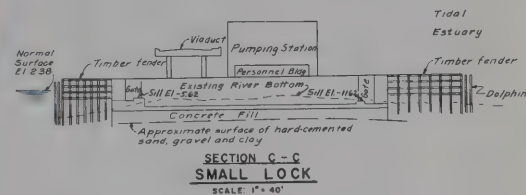
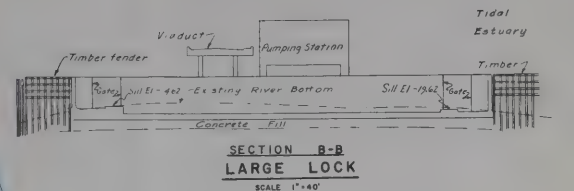
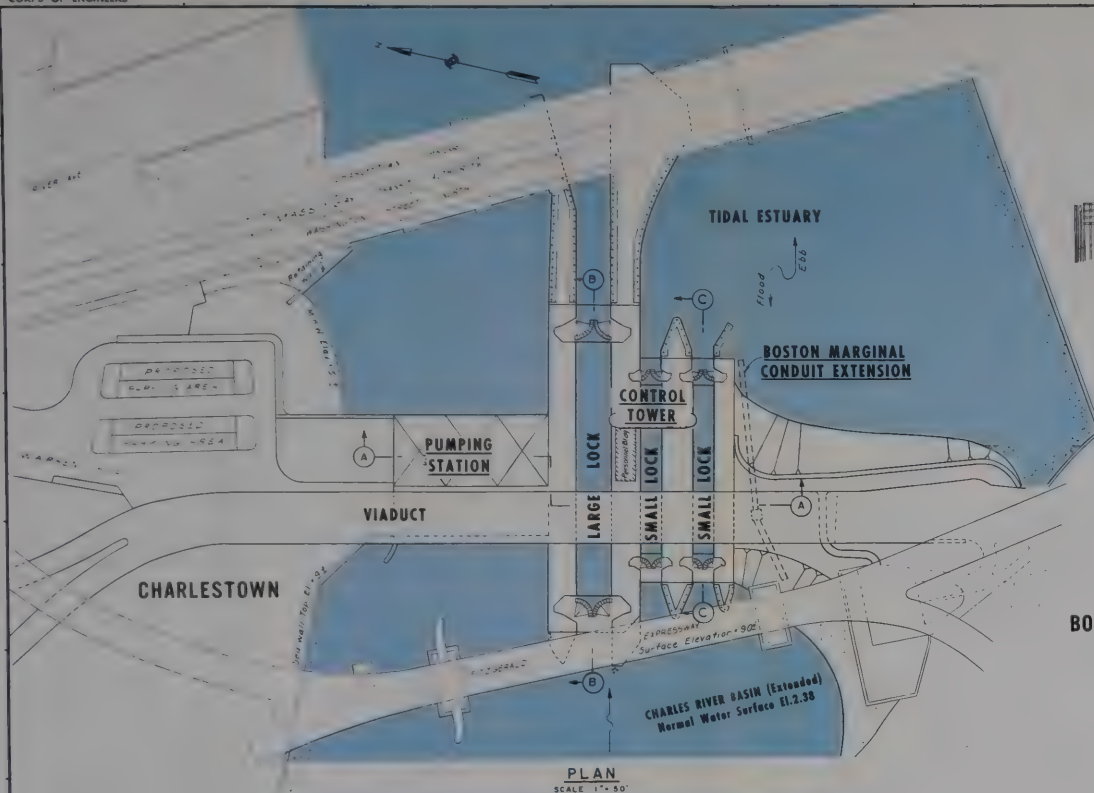


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CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER	
PLAN AND PROFILE	
NO. 101 J.C. G.H.D. 2.F.D.	MASSACHUSETTS
DATE: MAY 1950	DATE: MAY 1950
TO ACCOMPANY REPORT DATED MAY, 1950	SCALE AS SHOWN SHEET NUMBER

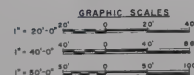
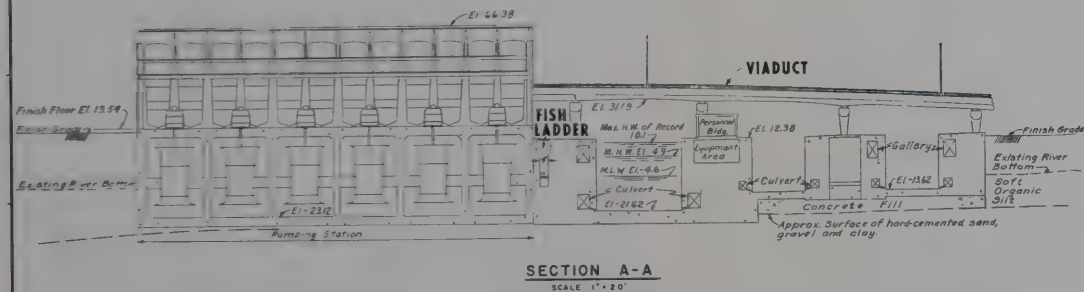




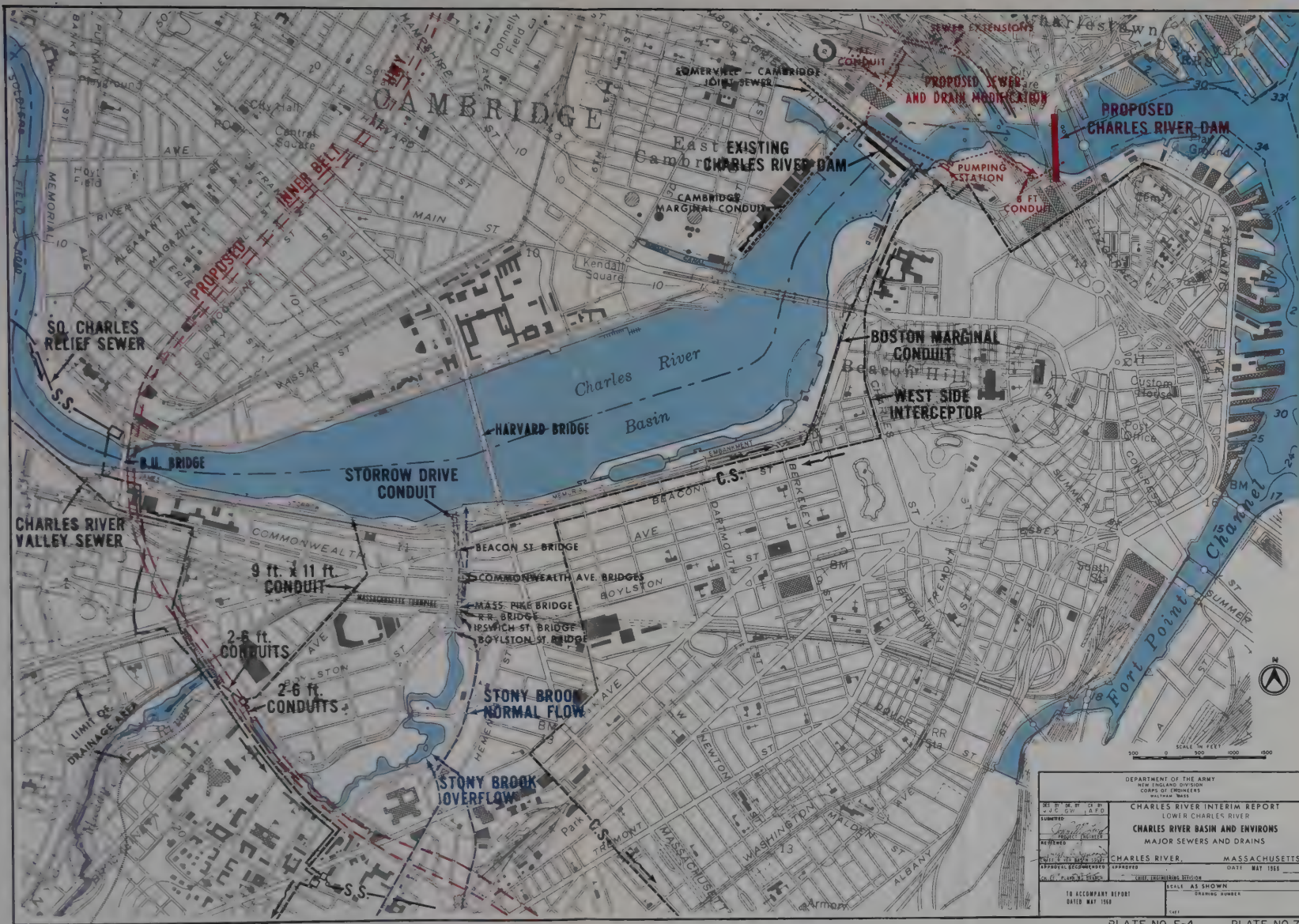
DEPARTMENT OF THE ARMY NIA ENGLAND DIVISION CORPS OF ENGINEERS	
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER CHARLES RIVER BASIN ELEVATION CONTROL ALTERNATIVE SITES CONSIDERED	
APPROVED J. C. M. S. A. F. D. J. C. M. S. A. F. D. J. C. M. S. A. F. D.	MASSACHUSETTS DATE MAY 1961
TO ACCOMPANY REPORT DATED MAY 1961	ENGINEER NUMBER



All elevations refer to MSL Datum



DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.	
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER CHARLES RIVER BASIN ELEVATION CONTROL PROPOSED CHARLES RIVER DAM PLAN AND SECTIONS	
DESIGNED BY ENGINEER CHECKED BY SUPERVISOR DATE APPROVED BY DATE	CHARLES RIVER, MASSACHUSETTS DATE MAY 1958 SCALE AS SHOWN ORIGINAL NUMBER SHEET
TO ACCOMPANY REPORT DATED MAY 1958	



DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS BOSTON, MASS.	
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER CHARLES RIVER BASIN AND ENVIRONS MAJOR SEWERS AND DRAINS	
DATE: MAY 1958 DRAWN BY: [Signature] CHECKED BY: [Signature] APPROVED: [Signature]	CHARLES RIVER, MASSACHUSETTS DATE: MAY 1958 SCALE: AS SHOWN DRAWING NUMBER: 1041

ATTACHMENT I

Information Called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

LOWER CHARLES RIVER WATERSHED
MASSACHUSETTS

ATTACHMENT I

INTERIM REPORT

LOWER CHARLES RIVER WATERSHED, MASSACHUSETTS

Information Called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

1. INTRODUCTION

The information in this supplement is furnished in response to Senate Resolution 148, 85th Congress, adopted 28 January 1958.

2. PLAN OF IMPROVEMENT

The impoundment known as the Charles River Basin has frequently exceeded its normal pool level causing flooding of adjacent areas of intensively developed urban land and tributary flooding. The plan of improvement that would best alleviate the flood problem while providing urgently desired expansion of facilities for navigation in the Basin is described briefly in succeeding paragraphs and more fully in paragraphs 41-46 of the main report and in Appendix F.

a. Description. The selected plan of improvement for the Charles River Basin provides for construction of a new dam with pumping facilities, 3 navigation locks, a fish ladder and overhead highway viaduct. The new dam, located downstream of the existing structure, will extend the present basin by about 2,250 feet.

Of the 3 locks, two are of smaller size, and will be used by recreation craft. The other, larger lock, will be used for commercial traffic, principally oil barges and tugs, and for large pleasure boats. It will also supplement the other locks at peak use periods.

In operation the 8,400 cfs pumping station will discharge from the basin at times when the tidal level is higher than the normal basin level of 2.38 feet, msl, and when major flooding requires it. Gated filling conduits along the sides of each lock will carry the discharge at times when the tide is lower than the basin water level and at times of moderate rainfall.

Lock operation will minimize the intrusion of salt water during high tide. Lock pumps, to lower the lock level, will draw from the lower portion of the lock containing a concentration of the heavier, salt water and will discharge this to the harbor.

Construction of the new dam will entail sewerage modifications to prevent the emptying of sewage between the locations of the existing and proposed new dam. Current proposals to improve the flow conditions and prevent overflows of combined sewage and runoff to the Basin that now occur will be incorporated in the plan of modification.

b. The effect of the improvement. The project will effectively control Charles River Basin flooding by providing for a dam and pumping facilities which can maintain the design water level in the basin regardless of tidal levels in the harbor. The locking facilities in the new dam, in contrast to the outmoded gates and inadequate lock now in use, will accommodate present and expected increased volume of recreational boat traffic and the expected amount of commercial traffic.

In addition to fulfilling the primary purposes of flood control and improvement of navigation with resulting benefit to recreational boating, the recommended plan will enhance fish and wildlife resources by providing a fish ladder in the dam and by reducing pollution by salt water intrusion through the operation of the locks.

In addition, the dam will support a highway viaduct as requested by local interests and provide access between Boston and Charlestown.

c. Economic life. The estimated project life used in the economic analyses in the report is 100 years for flood control and 50 years for navigation and transportation. Navigation and transportation costs and benefits were converted to 100 year series for compatible analysis.

3. PROJECT COSTS

Project first costs are based on average bid prices for similar work in the same general area adjusted to 1968 price levels. Valuation of property is based on the Market Data approach and reflects

recent sale values in the area. Land costs are based on the estimated fee value. All estimates include allowances for contingencies and costs for engineering and overhead. The investment consists of costs financed by Federal as well as non-Federal interests together with interest during construction computed at $3\frac{1}{4}$ percent based on the annual incurrence of these costs each year of a 3-year construction period. Tables 1 and 2 in the main report present summaries of costs and benefits for the recommended project. Annual charges predicated on 50- and 100-year project life are shown in Table I-1.

4. BENEFITS

The total average annual tangible benefits that are to be realized from the project are shown below:

<u>Source of Benefit</u>	<u>Project Life</u>	
	<u>100-Years</u>	<u>50-Years</u>
Flood control	\$1,660,000	\$1,558,000
Navigation	489,000	460,000
Transportation	<u>68,000</u>	<u>78,000</u>
Total	\$2,217,000	\$2,096,000

Excess benefits over costs and benefit-cost ratios are shown in Table I-1.

5. INTANGIBLE BENEFITS

In addition to the tangible benefits listed above important intangible benefits will be realized by the recommended improvement of the Charles River Basin. Among these intangibles are the possible prevention of loss of life, prevention of disease caused by flooding with polluted waters and the promotion of stability in the communities of the basin by reduction of the flood threat. The improvement of the fish and wildlife resources through the addition of a fish ladder and reduction in pollution to be effected by operation of the project will augment the aesthetics of the river, an additional intangible benefit.

6. PHYSICAL FEASIBILITY AND COST OF PROVIDING FOR FUTURE NEEDS

All foreseeable future needs have been considered in formulating the plan of improvement. The new dam with the provision for pumping discharges against a high tide in the harbor will reduce the possibility of flooding in the Basin at times of major floods. Provisions in the plan for navigation and the enlargement of the lower basin area will meet present and future needs of commercial navigation and recreational boating.

7. ALLOCATION OF COSTS

Table I-1 in this attachment summarizes the results of allocating project costs using three methods of allocation, (1) the separable cost-remaining benefit method, (2) the priority of use method, and (3) the incremental cost method. Computations were made using both a 50-year project life and a 100-year life.

8. EXTENT OF INTEREST IN THE PROJECT

The improvement of the Charles River Basin is urgently desired by local interests. The Governor of Massachusetts designated three state agencies to be represented on a coordinating committee made up of Federal and State representatives. In addition, a citizen advisory committee, representing the cities and towns in the watershed, was created to facilitate communication between the interested groups and agencies.

Letters of comment and concurrence appear in Appendix I of this report.

9. REPAYMENT SCHEDULES

Since navigation benefits derived from the improvement are entirely recreational in nature, the policies applicable to recreation navigation will apply. Local interests will contribute 50 percent of the first cost of the general navigation facilities allocated to navigation, a sum presently estimated at \$2,750,000. Costs of the structural features allocated to the highway transportation purpose of the project--included at the request of local interests--will be totally reimbursable to the United States and amount to an estimated \$1,430,000. In addition, local interests will bear all

costs of operation and maintenance of the project, including allowances for major replacements, an amount currently estimated at \$184,000 annually.

10. EFFECT OF PROJECT ON STATE AND LOCAL GOVERNMENTS

The project will have no adverse effect on state and local governmental services since schools, police and fire protection, utilities, and other public services are already provided in the area.

Tax revenues should increase upon construction of the project as a result of increased values of properties no longer subject to flooding.

11. PROPOSED INCREASE IN APPROPRIATIONS

The construction of the recommended project will require a Federal appropriation of \$18,620,000 for the Charles River Basin.

TABLE I-1

SUMMARY OF COST ALLOCATIONS
WARREN AVENUE MULTIPLE-PURPOSE DAM
(in \$1,000 at 1968 Price Level)

100-YEAR PROJECT LIFE					50-YEAR PROJECT LIFE			
	<u>Flood Control</u>	<u>Navigation</u>	<u>Transportation</u>	<u>Totals</u>	<u>Flood Control</u>	<u>Navigation</u>	<u>Transportation</u>	<u>Totals</u>
<u>SEPARABLE COSTS REMAINING BENEFITS METHOD</u>								
Allocated First Cost	17,570	7,390	1,540	26,500	18,430	6,510	1,560	26,500
Allocated Annual Charges	694	377	60	1,131	857	376	72	1,305
Annual Benefits	1,660	489	68	2,217	1,558	460	78	2,096
Excess Benefits Over Costs	966	112	8	1,086	701	84	6	791
Benefit:Cost Ratio	2.4	1.3	1.1	2.0	1.8	1.2	1.1	1.6
<u>PRIORITY OF USE METHOD</u>								
Allocated First Cost	22,600	3,010	890	26,500	22,580	3,010	910	26,500
Allocated Annual Charges	893	204	34	1,131	1,051	213	41	1,305
Annual Benefits	1,660	489	68	2,217	1,558	460	78	2,096
Excess Benefits Over Costs	767	285	34	1,086	507	247	37	791
Benefit:Cost Ratio	1.9	2.4	2.0	2.0	1.5	2.2	1.9	1.6
<u>INCREMENTAL COST METHOD</u>								
Allocated First Cost	23,070	2,420	1,010	26,500	23,050	2,430	1,020	26,500
Allocated Annual Charges	912	180	39	1,131	1,073	185	47	1,305
Annual Benefits	1,660	489	68	2,217	1,558	460	78	2,096
Excess Benefits Over Costs	748	309	29	1,086	485	275	31	791
Benefit:Cost Ratio	1.8	2.7	1.7	2.0	1.5	2.5	1.7	1.6

APPENDIX A
DIGEST OF PUBLIC HEARINGS

APPENDIX A

DIGEST OF PUBLIC HEARINGS

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APPENDIX A

DIGEST OF PUBLIC HEARINGS

1. INTRODUCTION

Public Hearings were held in Waltham, Wellesley and Franklin on January 17, 19 and 24, 1967 respectively. This digest has been developed from the minutes of the three hearings conducted by the Corps of Engineers, New England Division. As similar statements may have been presented at more than one hearing, a resume of statements is submitted with a notation as to the hearing or hearings at which it was presented. The contributors have been grouped as shown on the following table of contents.

2. MEMBERS OF U. S. HOUSE OF REPRESENTATIVES

- a. Honorable Philip J. Philbin, Representative in Congress
(Franklin Hearing)

Telegram expresses regret that cannot attend. Reports that President's budget requests additional \$140,000 for Charles Basin study. Thankful that Franklin hearing will cover problems of upper basin. Is sure that local testimony will pinpoint such problems as flood control for flash-type flooding, pollution, wildlife preservation, recreational needs and land use.

3. STATE SENATORS

- a. Honorable Oliver F. Ames, 3rd Suffolk District (Waltham Hearing)

States that many varieties of pollution exist in the Charles River. Serious problem of fumes and odors is caused by salt water admitted by dam at foot of the basin. He hopes the needed construction of new dam would qualify for Federal assistance. The flow rate of the river should be augmented. Has called for dredging and cleaning of Muddy Brook which is now a stagnant ditch, but flow and improvement depend on steps for improving Charles River. Coordination of pollution control is vital for permanent progress in improving the Charles. Attention should be given to aesthetics, during improvement, keeping in mind the original design conceived by great architects.

- b. Honorable James DeNormandie, Fifth Middlesex Senatorial District (At Waltham)

Says problems of Charles River are elimination of pollution; water augmentation; acquisition of maximum amount of land adjacent to river for recreation; and flood control, principally affecting lower basin.

Augmentation not easy to accomplish here because difficult to establish storage areas. Suggests Corps study possibility of increasing storm storage capacity of MDC water supply system for augmentation of the Charles in dry months. There should be a maximum realistic land acquisition program and many old buildings should be removed to restore land to open space for recreation and the pleasure of the neighborhood. Values from upgrading of property and recreation will repay many times over the cost of cleaning up the river. Urges restoration of the Charles be accomplished in as natural a manner as possible.

- c. Honorable John F. Quinlan, Second Norfolk District (Statement read by a representative at Franklin Hearing)

Senator Quinlan is most interested in the opinions of the various groups concerning the study. Chairmanship of a March of Dimes dinner prevents him from attending.

4. REPRESENTATIVES TO THE GENERAL COURT

- a. Honorable John St. Cyr, 12th Norfolk District (Franklin Hearing)

Says we cannot ignore a river like the Charles for years and then solve problems at once. Hopes the investigation will lead to legislation giving benefits from the Charles. Is aware of problems of too much or too little water. Hopes Federal and state governments can cooperate in a project such as that at North Adams on Hoosic River. Our problems are control of the uses of Charles River so that it may be source of pure water and recreation.

- b. Honorable Maurice E. Frye, Jr., 3rd District, Boston (Waltham Hearing)

Hopes for ultimate answer to problem of pollution in Charles River so that river can be used for recreation. Clearing of Muddy River is necessary and preferable to enclosing it in a culvert.

5. REPRESENTATIVES PRESENT AND ACKNOWLEDGED

Honorable Charles Flaherty, of Cambridge (at Waltham Hearing)
Honorable Charles W. Long, of Westwood (at Waltham Hearing)
Honorable Edward M. Dickson, of Weston (at Wellesley Hearing)

6. FEDERAL COORDINATING COMMITTEE MEMBERS

a. Corps of Engineers

- (1) Colonel Remi O. Renier, U. S. A., Acting Division Engineer, New England Division, U. S. Army Corps of Engineers; Chairman of the Coordinating Committee for the study of the Charles River Watershed.

Colonel Renier presided at all three hearings and outlined the ground rules for the conduct of the hearings and procedures to be followed in the study.

- (2) Mr. Edward L. Hill, Chief, Planning Branch of the New England Division described the watershed and specific known problem areas at the three hearings.

b. United States Department of Agriculture

- (1) Karl R. Klingelhofer (Waltham and Wellesley Hearings)

The Department will assist in preparation of the plan for conservation and development of the water and related land resources to obtain information on present and prospective land uses. The Soil Conservation Service has made soil surveys for several towns in the watershed. The Department can also assist in the appraisal of rural community water problems and the potential for water resource development, particularly in the upstream areas.

- (2) Henry J. Ritzer (Franklin Hearing)

Mr. Ritzer described the participation of the Department exactly as outlined by Mr. Klingelhofer in the two preceding hearings.

c. Department of Commerce

- (1) Alfred Anderson (Waltham Hearing)

Mr. Anderson stated that he is a representative of the Economic Development Administration of the Department, whose specific interest is with the economic projections developed during the study, with particular reference to areas specifically designated for assistance under the Public Works and Economic Development Act of 1965.

c. Department of Commerce (continued)

(2) Arthur Doyle (Franklin Hearing)

Mr. Doyle stated that as a representative of the Economic Development Administration he can offer cooperation and assistance in the study.

d. United States Department of Health, Education, and Welfare

(1) Alfred V. Soukup (Wellesley and Franklin hearings)

Mr. Soukup represents the United States Public Health Service of the Department. Health aspects of Charles River study must be considered, particularly with reference to the effects of water and related land resources developments upon insects of public health significance. He pointed out that use of recreational facilities in some New England areas has been greatly reduced by insect pests, and cited the possibility that mosquitos and aquatic species may increase in the vicinity of impoundments. The Public Health Service will also concern itself with public health aspects of water quality where water is used for domestic supply, bathing and water contact recreation.

(2) Frank Tetzlaff (Waltham Hearing)

Mr. Tetzlaff outlined the participation of the Public Health Service in a similar manner as that described by Mr. Soukup.

e. United States Department of Housing and Urban Development

(1) Sirrouko Howard (Wellesley Hearing)

He stated that the Open Space and Beautification programs of the Department might be integrated into plans for the watershed to good advantage. Both programs permit installation of basic recreational facilities. He intends to look into possibilities for dovetailing these programs into other state and federal efforts without overlapping.

f. United States Department of Interior

(1) James W. Lambie (Wellesley hearing)

He represents the Federal Water Pollution Control Administration in the Department with basic responsibilities in the

determination of need for flow augmentation and value of water resource development for meeting desired water quality needs. The studies on flow augmentation will be coordinated with the MDC, MAPC and the Massachusetts Division of Water Pollution Control.

(2) Walter M. Newman (Waltham and Franklin hearings)

Also represented Federal Water Pollution Control Administration of the Interior Department with responsibilities as outlined by Mr. Lambie, above.

7. OTHER FEDERAL AGENCIES

a. United States Army Corps of Engineers, New England Division

(1) Joseph L. Ignazio, Chief of Basin Planning Section,
(Wellesley Hearing)

In reply to a question from the floor, Mr. Ignazio advised that his section is collecting data on the various ranges of river flow in cubic feet per second.

In reply to another question relating to new research methods as applied to the Charles River Basin, Mr. Ignazio referred to such techniques as device for simulating rain storms, and to the extensive and long experience in the New England area.

b. United States Department of Agriculture

(1) Peter W. Larson, Agricultural Agent, Soil Conservation Service (Franklin Hearing)

Offers assistance of the Extension Service, and cites long experience with area landowners and more recent assistance to town conservation commissions. Asks for consideration for agricultural owners in land acquisition.

c. United States Department of Interior

Statement from the Fish and Wildlife Service (Waltham Hearing) to be entered into records. This refers to a Review Draft Report covering various aspects of Fish and Wildlife problems in the watershed and suggests impoundments for wildlife benefits. Report to be reviewed by the coordinating committee.

8. STATE COORDINATING COMMITTEE MEMBERS

a. Metropolitan District Commission

- (1) Howard Whitmore, Jr., Commissioner (Waltham and Wellesley Hearings)

Outlined background of the MDC and delineated area of the Charles River Basin under MDC jurisdiction. Commission serves 17 of the 28 basin cities and towns. The MDC Park system acquires and develops river lands, owns more than 1,800 acres in the Basin expressed as $25\frac{1}{2}$ linear miles of riverbank and controls an additional 3.6 miles, the total being equivalent to 80.5% of total riverbank miles. The MDC sewerage system serves numerous basin communities. Future construction of the new south-north relief conduits will increase capacity for removal of sewage which now overloads mains. At present old systems combine sewage and storm water in one drain. Plans for overload storage will reduce sewage input into Charles River. MDC water supply system extends 70 miles from Boston. Studies to find new water supply sources are in progress, including analyses of diversion from the Connecticut and Millers Rivers. Legislation permits discharge of up to 15 mgd for a maximum of 500 million gd per year into Charles River to dilute pollution in drought periods. Some proposed recreational developments on Charles River include a fishway at Cordingly Dam and small boat locks at the Charles River dam which will reduce salt water intrusion into the basin. He also listed a number of proposed projects, including channel improvements, recreational development and acquisition for recreation and conservation areas.

- (2) Max H. Straw (Franklin Hearing) Engineering Asst. to Comm'r.

Outlined the history, functions and future projects planned in the Basin along the same lines as indicated by Commissioner Whitmore.

b. Massachusetts Department of Natural Resources

- (1) Arthur Brownell (Franklin Hearing)

Offered the services of the Department.

- (2) Hans Van Leer (Wellesley Hearing)

Outlined the services which could be rendered to the study through town conservation commissions and soil conservation districts.

b. Massachusetts Department of Natural Resources (continued)

(3) Albert Zabriskie (Waltham Hearing)

Offered the services of the Department through the Divisions of Forests and Parks, Law Enforcement, Fisheries and Game, Marine Fisheries and Water Resources.

9. OTHER STATE OFFICIALS

a. Metropolitan Area Planning Council

(1) Miss Julia Broderick, Planner (Waltham and Wellesley Hearings)

Cites authority for Council to prepare plan for physical, social, and economic improvement of the District; guidelines for development aim to "conserve the water bodies, watersheds, and natural drainage areas."

Policy is to reclaim inland coastal waters and provide for continued purity. Careful conservation practices are imperative. Speaker cites the importance of water resources in eastern Massachusetts. In view of present and projected use of water resources, pollution is an intolerable waste. The Council's position is that our inland waters would be protected through public ownership or control. Council will submit detailed plan for the Charles River. Recommends that Corps of Engineers incorporate in comprehensive study program the following: a series of reports and meetings with local communities; participation of the Department of Interior (Bureau of Outdoor Recreation) and other appropriate Federal agencies; recommendations for ways of Federal financing of protection and maintenance of water resources; analysis of the various proposals for ponding, dredging, and canal extensions; hydrological data, a study of flood and flow regulation that leave countryside as natural as possible; study of conservation areas and reports on aesthetic qualities of various areas; consideration of Charles River Park system; studies of water quality, anadromous fish, effects of motor boating, drainage problems, upstream pollution, and the relationship of Mother Brook to the total Charles and Neponset system. Should establish priorities for development and formulate necessary legislation to protect and enhance Charles River as an open space and recreational resource.

a. Metropolitan Area Planning Council (continued)

(2) William Melia (Franklin Hearing)

Same statement as given by Miss Broderick.

b. Massachusetts Bay Transportation Authority

(1) Rush B. Lincoln, General Manager (Waltham Hearing)

Letter which reads "The Authority supports the study especially as it relates to flood control of Muddy River. Existing MDC flood control work gives insufficient protection for Highland Branch, transit tracks, Kenmore subway and contiguous areas. Authority has filed legislation requiring MDC study."

c. Massachusetts Department of Natural Resources

(1) Richard Cronin, Division of Fisheries and Game (Franklin hearing)

Entered a statement on behalf of the Division. The principal points outlined included: high recreational demand in watershed and a high fishing and hunting potential, presently unfulfilled. Potentials to support runs of shad, herring and salmon, and other resident cold and warm water fish. Marshes have potential for waterfowl, and uplands for upland game. The Division has completed a more detailed report in cooperation with the U. S. Fish and Wildlife Service.

(2) Leigh Bridges, Division of Marine Fisheries (Franklin Hearing)

Proposed fish restoration efforts from the mouth to headwaters and specified dam improvements, alterations and the installation of fish passages for anadromous fish at Charles River, Bleachery, Moody Street, Washington St., Cordingly, Boylston St., Upper Newton Falls, Silk Mill, Charles River Village, and South Natick dams. Strongly urged the Corps to include anadromous fish restoration in its plans, and to work cooperatively with the Division of Marine Fisheries for this purpose.

d. Massachusetts Department of Public Works

(1) Edward J. Ribbs, Commissioner (Waltham Hearing)

Sends telegram requesting an accelerated flood study of Muddy River and Stony Brook since they may be altered and relocated in Inner Belt highway construction.

e. Massachusetts Historical Commission

(1) Richard Hale, State Archivist (Franklin hearing)

Stated the Charles River valley has great historic assets - 10,000 years of pre-history, and 400 years of history. Offered the co-operation of the Historical Commission in this study.

10. GARDEN CLUB FEDERATION OF MASSACHUSETTS

a. Mrs. Ruth Burke (Waltham Hearing)

Stresses importance of restoring river bank areas to former natural state after engineering construction work.

b. Mrs. Franklin Sanders (Wellesley Hearing)

Proposes consultation with competent landscape architects and garden clubs in landscaping river areas, and plans to include preservation through careful selection of plant material. Urges restoration of banks following any engineering work, and full regard for the importance of native plants in erosion control and shoreline protection.

11. MASSACHUSETTS ASSOCIATION OF CONSERVATION COMMISSIONS

a. Mrs. Earl H. Bourne (Franklin Hearing)

Enters a statement on behalf of the board of directors of the association, approving the aims of the Charles River Watershed Association, in the ultimate use of the Charles River, the protection of its watershed, and the preservation of major conservation areas along its course.

12. MASSACHUSETTS FOREST AND PARK ASSOCIATION

- a. Benjamin W. Nason, Executive Director (Franklin Hearing)

The principal concern of the Association is the inadequacy of the Charles River to serve growing water supply and active and passive recreational needs of residents and visitors. The problem will grow worse unless pollution sources are brought under control and the destruction of river banks and adjacent wetlands is stopped. The Association will give support to dredging projects only if absolutely essential for flood control, but will not support such projects if only of marginal value, on the grounds that such projects invite industrial and home developments in flood plains. Suggests state legislation further restricting new developments in flood plains.

4. MASSACHUSETTS WILDLIFE FEDERATION

- a. Lester B. Smith, Chairman of the National Affairs Committee (Waltham and Wellesley Hearings)

The Federation recommends that the Bureau of Outdoor Recreation and the Massachusetts Division of Fisheries and Game be added to the Coordinating Committee. (Wellesley Hearing).

Asks Colonel Renier whether it will be possible to complete the Charles River study in less than five years. (Waltham Hearing).

IV. REGIONAL ORGANIZATIONS

13. CHARLES RIVER WATERSHED ASSOCIATION

- a. F. E. Whitmarsh, President (Waltham Hearing)

Is disturbed that economic justification is proposed for the undertakings of the watershed plans. Believes there may be too much emphasis on the pollution aspect, since the chief values are recreational. Recommends immediate land acquisition program to protect the presently unspoiled riverbank areas not under public ownership or control, before land is taken by business, industry or developers of housing developments. Urges that One agency be responsible for entire river. Recommends that the banks of the Charles be held in public trust forever.

b. Richard J. Alexander, Planning Consultant for Association

Recommends that Recreation elements be emphasized throughout the course of the study. Calls for early interim recreational plans and for a land acquisition fund. Proposes intensive study of lands surrounding portion of basin which would be created by proposed Warren Avenue dam. Suggests study of the following: possible adverse effects on landscape in the event Memorial Drive is converted from a parkway to a standard arterial highway; disposition of Watertown Arsenal and how this could fit the comprehensive plan. Cites the mis-use of river banks from Watertown dam to Natick, listing dumps, parking lots, open storage areas and buildings in the wrong places, as examples.

c. Kenneth Wood, Vice President (Franklin Hearing)

Points to the different character of the upper end of the Charles River from the downstream portion. The spread-out population density has not precluded overdevelopment in areas. He repeats the main belief of the Watershed Association that the primary consideration should be that the Charles River is a permanent recreational watershed. Suggests the feasibility of establishing boundaries of the flood plains, so that the Hatch Act or any type of legislation will be easier to implement locally. Calls for protection of the watershed, and referral system among agencies and the Association to avoid unforeseen encroachment on recharge areas by any type of development, before they commence. Suggests small structures in tributaries for water retention, for flood control, low flow augmentation and recreational use. The Association believes water quality should be of a "B" classification. Urges regulation of motor boating on Charles, and requests that such groups as the League of Women Voters and the Charles River Watershed Association be represented on the Citizens' Committee. Pledges cooperation of the Association.

14. CHARLES RIVER VALLEY GROUP, LEAGUE OF WOMEN VOTERS

a. Mrs. Alexander Liveright (Waltham Hearing)

League feels that recreational use far outweighs any other possible uses. Discusses present uses of river including transportation by barges; dumping by municipalities and by industries, with problem areas specified in areas. Hopes that any new buildings near the river under redevelopment programs be aesthetically attractive and suggests

a. Mrs. Alexander Liveright (Waltham Hearing) (continued)

the formulation of a design code for construction. Mentions great boating potential of river. Proposes that all parking lots be removed inland from the riverbanks, and more public access for walkers and cyclists be provided. Expresses hope that the Inner Belt will not worsen the Muddy River problems. (The League proposes more detailed recommendations contained in Exhibit 8.)

b. Mrs. Russell Haddleton (Waltham hearing)

Emphasized Mrs. Liveright's points and calls for coordination among all Federal, State, local and private agencies in the program. Notes that there are sixteen Leagues in the Watershed. Urges the proposed Citizens' Committee and further urges that this group have voice in the policy making.

c. Mrs. Robert A. Smith (Wellesley Hearing)

Cites great real estate pressure on Charles' banks in Wellesley area and hopes for a "green belt" type of preservation. Urges the following: preservation of natural banks, improvement of banks and nearby structures; set-back of parking lots from banks; landscaping after construction; set-back of commercial buildings when inevitable; discontinue building in flood plain zones; more access for canoes.

d. Mrs. Thomas P. Murray (Franklin hearing)

Is concerned with wetland preservation and cited Medfield's many acres of marshes, and wet lands. Re-stated the views of the above representatives as far as stream bank restoration and planting. Warns against urbanization of upper Charles River. Notes the great problem of flow in dry periods.

15. NEW ENGLAND WILDFLOWER PRESERVATION SOCIETY, INC.

a. Mrs. Alexander MacLeod, Director (Wellesley Hearing)

The Society supports the recommendations of the Citizen's Panel, Aesthetic Considerations, Corps of Engineers Water Resources Development Projects in New England. Cites instances of red maples being killed along the Charles River and urges methods to prevent further loss of red maples.

16. NORFOLK CONSERVATION DISTRICT

a. William Sweet, Chairman (Franklin Hearing)

Offers cooperation of District to Corps study. Stresses need for wise management of tributaries. The District memorializes the Corps to: (1) guarantee protection of wetlands in perpetuity; (2) develop recreation facilities on specified tributaries; (3) watershed regional planning; (4) implement a soils inventory of watershed towns; (5) prepare a recreational inventory.

17. CITY AND TOWN PUBLIC AGENCIES

a. Boston

(1) Hon. John F. Collins, Mayor (Waltham hearing)

Telegram received states that representatives of the City will attend hearings as observers.

(2) City Council (Waltham hearing)

Entered statement into record - Exhibit #16. Urges the Corps to work to end pollution of Charles River; to consider the waterfront, Boston Harbor and Neponset River Valley as one contiguous area and develop far-reaching plans in accord with this concept.

(3) Boston Redevelopment Authority

John Stainton (Franklin hearing)

Particularly concerned with shoreline and banks of Charles along boundaries of city of Boston. Proposes to leave with the Corps two recent studies - Boston General Plan 1965-1975, and the North Terminal Area study. Points to pollution problems of municipal dump in West Roxbury, adjacent to river. Is concerned about continued public access, a disappearing resource; with the potential of Mother Brook. Mentions other problem areas - Gardiner Street municipal dump, Warren Avenue proposed dam, the Muddy River as affected by dredging and the construction of the Inner Belt. The BRA plans series of studies to evaluate master plans affecting the Charles River. Welcomes interim reports and progress studies undertaken by the Corps, and hopes for a continuing mutually beneficial relationship with the Corps in the development of plans for the use of the Charles River.

b. Town of Dedham

(1) Board of Selectmen (Wellesley hearing)

The Selectmen's basic concern is the preservation of flood plains in natural state for flood control and aesthetic reasons. Dedham plans to accomplish this on a time schedule through zoning and acquisition.

(2) Conservation Commission, Elizabeth W. Berle, Secretary
(Wellesley hearing)

The statement of the Selectmen and Conservation Commission is jointly entered into the record.

c. Town of Dover

Conservation Commission, Mrs. Harriet W. Long, Chairman
(Franklin hearing)

Urges strong stand on protection of natural areas for: intangible values inherent in environmental beauty; passive recreation, canoeing and nature study; preserving fish and wildlife habitat. Hopes for public protection of the river, accessible to hikers. Believes that river should be zoned for boating, with adequate enforcement, and that motor boats should be banned in upper reaches for the following reasons: pollution of water; noise and nuisance; danger to wildlife; erosion of banks and destruction of fish nests by wash of speeding motor boats.

Mrs. Long turned over material marked Exhibit No. 4 - "Notes from a Naturalist, Observations on canoeing a short stretch of the Charles River, in the Medfield Marshes and Rocky Narrows, 1966".

d. Town of Franklin

George M. Doyle, Franklin Reservoir Survey Committee
(Franklin hearing)

States town's need for adequate drinking water due to population increase from 7,500 - 16,000 in last 10 years. Town proposes to take area south of new Route 495, Mine Brook, Dick's Brook and Miscoe Meadow for future reservoir site. Town has spent \$50,000 and Federal Government has contributed for feasibility study. Hopes for an 880-acre reservoir with capacity of 1.3 billion gallons.

e. Town of Medway

Conservation Commission, O. Scott Fader (Franklin hearing)

Suggests that much pollution derives from institutions along river and urges this as a first study.

f. Town of Natick

Conservation Commission, George H. Wallace (Wellesley hearing)

Conservation Commission has designated 180 acres in flood zone under a wilderness classification. Commission strongly urges the Corps to study the following: methods by which town can enact and enforce flood plain and conservancy zoning; impact of a proposed community college on the Stillman Property in South Natick; the feasibility of establishing an historical district in South Natick; the creation of small capacity storage ponds on South Natick and upstream tributaries; the sources of pollution. The Commission also proposes action by the Corps to expedite flood plain land acquisition through state and federal cost-sharing at an early stage in the planning of the Charles River. Urges coordination of all agencies involved.

g. Town of Needham

(1) Conservation Commission (Wellesley hearing)

Statement entered into the record and marked Exhibit No. 7. The Conservation Commission believes canoeing is top use of the Charles River. Town's flood plain zoning will help preserve canoeing opportunity. Advises that the Needham YMCA operates a canoe and small boat livery at Red Wing Bay, and that the only other canoe access point is on the Charles River Peninsula Reservation under ownership of the Trustees of Reservations. Needham's summer swimming facilities at Rosemary Lake are over-crowded.

(2) Planning Board (Wellesley hearing)

Hopes for full consideration of the preservation of ample flow and for pollution abatement which will result in an early "C" classification upstream from Waltham, with a "B" classification the ultimate aim. Board recommends state-wide enabling legislation to attain effective flood-plain zoning.

h. City of Newton

(1) Honorable Monte G. Basbas, Mayor (Wellesley hearing)

Letter entered into record.

(2) James A. Miller, Planning Director (Wellesley hearing)

Reads Mayor Basbas' letter urging broadening scope of the watershed survey study. This should be truly comprehensive; should inventory all data, define needs, establish goals, outline programs. He hopes the recommendations of Newton's and other neighboring communities' studies will be correlated and included in the watershed study. Corps should provide for interim or phased recommendations and procedure to disseminate them for use by communities during the study. Also Corps should analyze each major project by city, M.D.C., or other agency to assure consistency with long-range goals.

(3) City Physician, Hale M. Cook, M.D. (Wellesley hearing)
Health Department

Asks that inclusion of a bicycle path on both sides of the river be considered. Cites health values to families and police travel by motor scooter through this means of access.

i. City of Waltham

Paul W. Giunta, City Councillor (Waltham hearing)

Hopes this study will be carried to completion and not forgotten. Praises the efforts of the League of Women Voters in bringing active people together. Cited encroachments on MDC park lands over past 20 years and asks if this policy will continue or whether MDC will change to more effective control of their riverbank reservations.

j. Town of Wellesley

Conservation Commission, Warren Little, Chairman (Wellesley hearing)

States need for re-planting of banks between Newton Upper and Newton Lower Falls. Suggests installation of fishladder at Newton Lower Falls, and requests improvement and protection of the Hemlock Gorge Area off Worcester St. and a fishladder in this area also.

k. Town of Wrentham

Conservation Commission, Marjorie Taylor, Chairman (Franklin hearing)

The Commission hopes for elimination of pollution downstream, and the creation of a water storage reservoir in the Fenwood area below Eagle Brook. The Commission has a plan by Egbert Hans, landscape

architect of the Department of Natural Resources for recreational facilities and submits this map and plan.

18. PRIVATE AGENCIES

a. Boston

(1) Boston Society of Architects, Robert S. Sturgis(Wellesley hearing)

States he is Chairman of the Committee on Civic Design, which recommends that all Federal and State agencies having jurisdiction within the Charles River Watershed, including the Corps of Engineers, make their plans to reinforce the open space policies of the Metropolitan Area Planning Council.

(2) Boston Society of Landscape Architects

a. Vincent N. Merrill, (Wellesley hearing)

States that there is danger that the prime recreational potential of the entire river may be underrated on account of the reasonable concern for the engineering problems of pollution control. Hopes that a beautiful river will result, with opportunities for canoeist, rowing shells, passive recreation, nature study and walking and cycling. States that the Charles River is Boston's greatest natural recreational resource whose potential must be preserved and planned for this and future generations.

b. John Lee Wacker, President (Waltham hearing)

Charles River has been the concern of the Boston Society of Landscape Architects for 65 years. Hopes for a comprehensive master plan which will end conflicts and delays of the past for once and all. Offers a detailed plan for the study and expresses concern for the 5-year time gap before completion, and suggests local action through early interim plans and a strong land acquisition program. He lists the policies of the Society relative to the Charles River as follows: (1) Oppose any encroachment on park lands contrary to original purpose of acquisition; (2) preservation of wilderness areas; (3) conservation of natural scenery; (4) timely park land acquisition; (5) water conservation; (6) stream pollution must be halted by statutes which make pollution basis for criminal proceedings; (7) the collaboration of the design profession urged; (8) preservation of historic sites; and (9) open spaces preserved and acquired.

(3) Boston University, James A. True, Asst. to the Pres. (Waltham Hearing)

Boston University is fortunate to occupy a 45-acre strip of land between Commonwealth Avenue and the Charles River. Cites problems of University crew, numbering 50 men per day on the river. Damage to shells from floating objects and infections of blisters by river water contact. Suggests stricter traffic control during warmer months to resolve conflicts among shells, sailboats, canoes and power boats.

(4) Fenway Civic Association, Inc., Miss Roberta Chesnut, Pres. (Waltham hearing)

Is concerned with the condition of Muddy River. It is used for dumping and contains tons of rubbish and oil. Urges at least a short-term program now to clean it out. States that there is enough rubbish to employ 25 men for one month in the clean-up.

b. Dedham

(1) Citizens' Advisory Committee (Franklin hearing)

Is especially interested in the portion of Mother Brook in East Dedham, and the Urban Renewal Project in East Dedham Square which has aroused interest in cleaning up pollution, and the restoration of Old Mill Pond. The Dedham Conservation Commission has an article in the Warrant proposing that the brook from United Waste Co. to the Dedham-Hyde Park line be made a part of flood plain zoning. This project could help the needs of a Veterans' Housing Project and an Old Age Housing Project in the vicinity. Is also concerned at further ditching which may decrease the flow through Dedham. There is further concern that 300 feet of Mother Brook was buried underground at the Charles River Arcade last fall without as much as a public hearing or a discussion by the Selectmen until it was too late to prevent.

(2) Noble and Greenough School, F. B. Lawson (Wellesley hearing)

The school is generally in favor of retaining the river in its natural state and opposed to straightening on the basis that this might affect recreational uses of Motley Pond adversely. If it is necessary to straighten the river in this area, the School hopes that the skating area in the northwest cove of Motley Pond can be preserved; and that a straight stretch 120 feet wide and 3/4 mile in length can be made, since this would greatly improve the course for crew races and rowing conditions also.

c. Newton

Newton Conservators, Inc., B. F. Shattuck (Wellesley hearing)

Supports 1961 MDC plan for Charles River by Charles Eliot. Recreation is the first consideration. Cordingly Dam should be a combined engineering and park project. Recommend a study of natural areas around Hammond Pond; canoe access from Charles River Dam to Watertown; power boat restrictions; public control of banks from Upper Falls Playgrounds to Charles River Country Club; study of Webster Estate near Hammond Pond as a natural area; study of Shaw Estate near the river as a natural area; study of possibility of an historic district near Cordingly Dam. The Conservators call for a halt to the nibbling away of MDC park lands, and cite several examples.

d. Watertown

Watertown Yacht Club, John W. Grabski (Franklin hearing)

Cites shoaling of upper basin in Sunset Bay area, increase in floating debris and floating oils and pollution as hazards to boating. Requests study of the following: plan of new locks at Charles River dam; review of further diversion of salt water; dredging of Sunset Bay; pollution sources; and upstream impoundment of water to augment stream flow in dry spells.

e. Wellesley

(1) Wellesley Conservation Council, Franklin Sanders(Wellesley hearing)

This agency owns wildlife sanctuary areas on the river. The following areas are shown on the map of Parks and Public Lands; meander forming the boundary of Wellesley-Dover line from S. Natick to Needham; marsh lands between Routes 9 and 128; marshes between Cordingly Dam and Washington St., Lower Falls; both banks of the river from Washington St. through MDC holdings to Weston line.

(2) Wellesley Garden Club, Mrs. Sumner W. Ferris(Wellesley hearing)
Mrs. Joseph B. Fyffe " "

After lessening of the pollution, the Garden Club looks to recreation, scenic beauty, open space and Wildlife habitat. Hopes for a multi-purpose program, always aiming at preservation of a natural state. Recommends that the Corps review and adopt where possible the suggestions

- (2) Wellesley Garden Club, Mrs. Sumner W. Ferris
(Wellesley Hearing) Mrs. Joseph B. Fyffe (continued)

of the Citizens' Panel on Aesthetic Considerations, Corps of Engineers Projects, New England. Also urges the Corps to consult with the Garden Club's plan in the Lower Falls area, and to incorporate in its plan any ideas possible. A copy of plan can be made available.

- (3) Wellesley League of Women Voters, Mrs. Lydia Goodhue,
(Wellesley hearing)

Asked Commissioner Whitmore to explain how the Hatch Act might impair the work of MDC. Mr. Whitmore replied the authorities under the Hatch Act needed clarification.

- (4) Wellesley Park and Tree Board, Mrs. Mary H. Fyffe
(Wellesley hearing)

The Board recommends restoration and replanting on the following areas of the Charles River: Rte. 9 north to Rte. 128, MDC land and river; MDC land south from Weston line to Grossman's at Wellesley Lower Falls; Needham line upstream to River St., South Natick; and Rte. 128 downstream to Boulevard Rd., Wellesley. The Board questions the suitability of river lands on the Wellesley-Natick line for commercial development.

f. Weston

- Rivers Country Day School, Conservation Class,
William M. Cantor (Wellesley hearing)

Early interim land acquisition urged. Other recommendations of the Conservation Class include: beautification of the banks; purification of water with swimming a goal; recreational planning; solid waste disposal study; study of dredging to speed flow; multi-purpose engineering works, fishladders and beautification; and an educational program for residents of the watershed.

19. INDIVIDUALS

a. Cambridge

- Charles W. Eliot, Professional Planner and Landscape Architect
(Waltham hearing).

Refers to earlier planning of 1925 Bay Circuit study and to a study requested by MDC in 1960. Copies are available to the Coordinating Committee herewith, for the record. States that orthodox flood control structures are not appropriate to the Charles River - no rip-rap or smooth engineering lines. Cites historic interest of the mill dams. Recreation, active and passive, is the highest use of the river. He urges a concert of policies for all aspects, and unified control of the entire Charles River.

b. Medfield

Charles Cane, Resident of Medfield (Franklin hearing)

Urges public ownership as best means to control river and banks.

c. Medway

David Whitten, Medway Resident (Franklin hearing)

Believes the study is a good opportunity for coordinated efforts to enforce existing laws and regulations, especially the new Anti-Pollution Act.

d. Needham

John LeVert, Resident of Needham (Waltham hearing)

Requests clarification on objectives of Corps study and the new Federal legislation asking for pollution report by June 1967. Question was answered by Mr. Newman, U. S. Dept. of Interior on pp. 137-138 of minutes for the Waltham hearing.

e. Waltham

Charles English, interest in river excursion boats. (Submitted sketch at Waltham hearing)

States that many tourists travel on the Charles River excursion boats and that the odors and filth of the river are giving Boston a bad name outside of the state.

f. Weston

Charles MacLeod, Resident of Weston (Waltham hearing)

Requests information from Commissioner Whitmore regarding the exact amount of diversion from the Charles River to Mother Brook in Dedham, and if this diversion has any effect on the lower part of the Charles River.

g. Miscellaneous

Mrs. Walter Bradford Cannon, Franklin, N.H. (Waltham hearing)

Letter submitted (Exhibit 17). Hopes the government can protect the waters of the Charles River from its sources to its mouth.

APPENDIX B

HISTORY
URBANIZATION
AND
POPULATION

APPENDIX B
HISTORY, URBANIZATION AND POPULATION
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APPENDIX B

LOWER CHARLES REPORT AREA HISTORY, URBANIZATION AND POPULATION

INTRODUCTION

1. This Appendix reports the history and the urban development of the twelve river miles between Moody Street, Waltham, and Warren Avenue, Boston, in parts of ten municipalities, and the 56 square miles that drain to that twelve-mile reach of the Charles River, Massachusetts.

The Lower Charles Interim Report Area is about one-fifth, geographically, of the entire Charles Watershed, 307 square miles.

The Charles River Watershed is geographically and economically a part of the largest employment and population cluster in New England. This cluster is the northern terminus of Megalopolis, the Atlantic coastal urban strip between Washington and Boston, in which live about 44 million people, nearly one-fifth of the United States population.

In the Lower Charles Interim Report Area are the principal governmental, educational, medical, financial, and insurance institutions of New England. The cultural assets, universities, historic structures, and museum and library treasures found in this area are of national and international importance.

HISTORY

2. COLONIZATION

The Lower Charles Report Area is a major portion of the principal settlement in New England. Colonization of it began in the 1620's. Early settlements were made in Massachusetts Bay in what are now Weymouth and Braintree in 1623; in Naumkeag (Salem) 1624, in Boston Harbor, Nantasket, Shawmut (Boston) and Winnisimmet (East Boston and Chelsea) in 1624 and in Mishawum (Woburn) in 1625. This was part of the early 17th Century broad pattern of British and West European population movement to the North American Atlantic Coast, between the St. Lawrence River and the Savannah.

Following Columbus' series of voyages (1492 to 1504) explorers and fishermen for a hundred years visited the American Atlantic Coast

with increasing frequency. Fish drying stages, harbors of refuge, and watering and careening places for vessels had all been attracting settlement along the North Atlantic Coast. Reports of New England voyages in 1598, 1602, 1604 by Raleigh, Gilbert, Champlain, Gosnold and others, also the report and map by Captain John Smith of a 1614 voyage, drew attention to the shores and fisheries of Massachusetts Bay and environs. Smith named the subject river for Prince Charles of England, royal patron of Smith's 1614 voyage.

Events in England in 1628, 1629 and 1630 deeply influenced the future of the Charles River valley and of Massachusetts, and so, the nation. In March 1628, the English governmental Council for New England granted to a company of six gentlemen in England all land in Massachusetts between a line three miles north of the Merrimack River and a line three miles south of the Charles River, from the Atlantic Ocean to the Pacific Ocean. This is the origin of Massachusetts northerly and southerly boundaries.

The six gentlemen soon interested others and an enlarged number of joint proprietors assumed the title of "The Governor and Company of the Massachusetts Bay in New England." They chose Matthew Cradock, Governor. He never came to America, but his name is memorialized in the former Cradock Dam at Medford Square, on the Mystic River.

In June 1628, the Massachusetts Bay Company sent a small band of emigrants to settle at Salem. Captain John Endicott, one of the six original purchasers, was appointed local Governor of the little band, and acted under the orders and instructions of Governor Cradock in England.

On March 4, 1629, a crown charter for the government of the Massachusetts Bay Company was granted, said to be the only charter of its kind which did not require that the government of the corporation reside in England.

In July 1629, Governor Cradock proposed that the Company transfer the corporation government from England to the colony in America, and in August it was so voted. At a "Court" or business meeting of the Company in October 1629, Mr. John Winthrop was chosen Governor, and a body of "assistants" were chosen on the understanding they would accompany Winthrop to Massachusetts.

In April, 1630, nearly one thousand Massachusetts Bay Company people, with provisions, tools, cattle and household possessions, embarked from England in some seventeen ships for New England. This was the largest, best equipped and highest calibre expedition to the shores of North America before 1650. Most of the Massachusetts Bay Company ships reached Salem in May or June, 1630. The second ship reached Nantasket (Hull), then crossed the Bay to Mattapan where the passengers settled and called the place Dorchester.

Because of crowding in Salem and unsatisfactory water supply in Charlestown, many of the Company, under Sir Richard Saltonstall as local leader, went up the Charles River and settled Watertown. Other seekers after good water went over to Boston and to Roxbury.

"The first Court of Assistants (was) holden at Charlton (Charlestown) . . . 23 August 1630" (Massachusetts Bay Records, Vol. I, p. 73). September 7, 1630, it was ordered "that Trimontaine shall be called Boston. . ." (Mass. Bay Records, Vol. I., p. 75).

At the end of the year 1630 there were no municipalities as such, but there were a dozen river and seacoast settlements (Agawam, Naumkeag, Saugus, Winnisimmet, Medford, Charlestown, Watertown, Boston, Roxbury, Dorchester, Nantasket and (Weymouth) Wessagusset) all under the self-government of the Governor and Assistants of the Massachusetts Bay Company at Boston.

In December 1630, the Governor and Assistants feared the English Crown might attempt to seize the charter. The Boston peninsula was very exposed to naval attack, so a location on the Charles just below Watertown was chosen for a new town, which was to be fortified. It was planned to remove the ordnance and ammunition there; both general courts and particular courts were to be held there; and the Governor and Assistants agreed to build houses and live there. This was the genesis of New Town, later named Cambridge.

3. MUNICIPAL ORGANIZATION

All of the Lower Charles Report Area became settled and municipal boundaries were begun within the first six years from Massachusetts Bay Company arrival. Sixteen hundred and thirty is the common date for the founding of Charlestown, Boston, Dorchester, Roxbury, and Watertown. Cambridge, although palisaded in 1632 and then agreed to be the "Newe Towne," is regarded as established in 1636, Mass. Bay Rec., Vol. I, p. 180. These six communities embraced the whole Lower Charles Report Area, now divided among ten municipalities.

Much of Cambridge south of the Charles River was incorporated in 1691 as Newton. Muddy River Village in 1705 became the Town of Brookline. Weston was set off from Watertown in 1712 and in 1738, Waltham from Watertown. Cambridge Farms in 1713 became the Town

of Lexington, from which Lincoln was set off in 1754. Finally, in 1807, the remaining Cambridge South Parish became Brighton, and the West Parish, West Cambridge, which sixty years later was re-named Arlington. Somerville in 1842 was set off from Charlestown, and in 1859, Belmont, from parts of West Cambridge, Watertown and Waltham. In 1868, Boston annexed Roxbury, and in 1874, annexed Brighton, Charlestown, Dorchester and West Roxbury. These actions completed the municipal organization of the Lower Charles area.

The ten Lower Charles municipalities now are Arlington, Belmont, Boston, Brookline, Cambridge, Lexington, Newton, Waltham, Watertown and Somerville.

4. PHYSICAL ALTERATIONS OF THE CHARLES

Land-filling alteration of the coves and shores of the Boston peninsula and bridging and filling of the Charles River Estuary began within the first two decades of settlement.

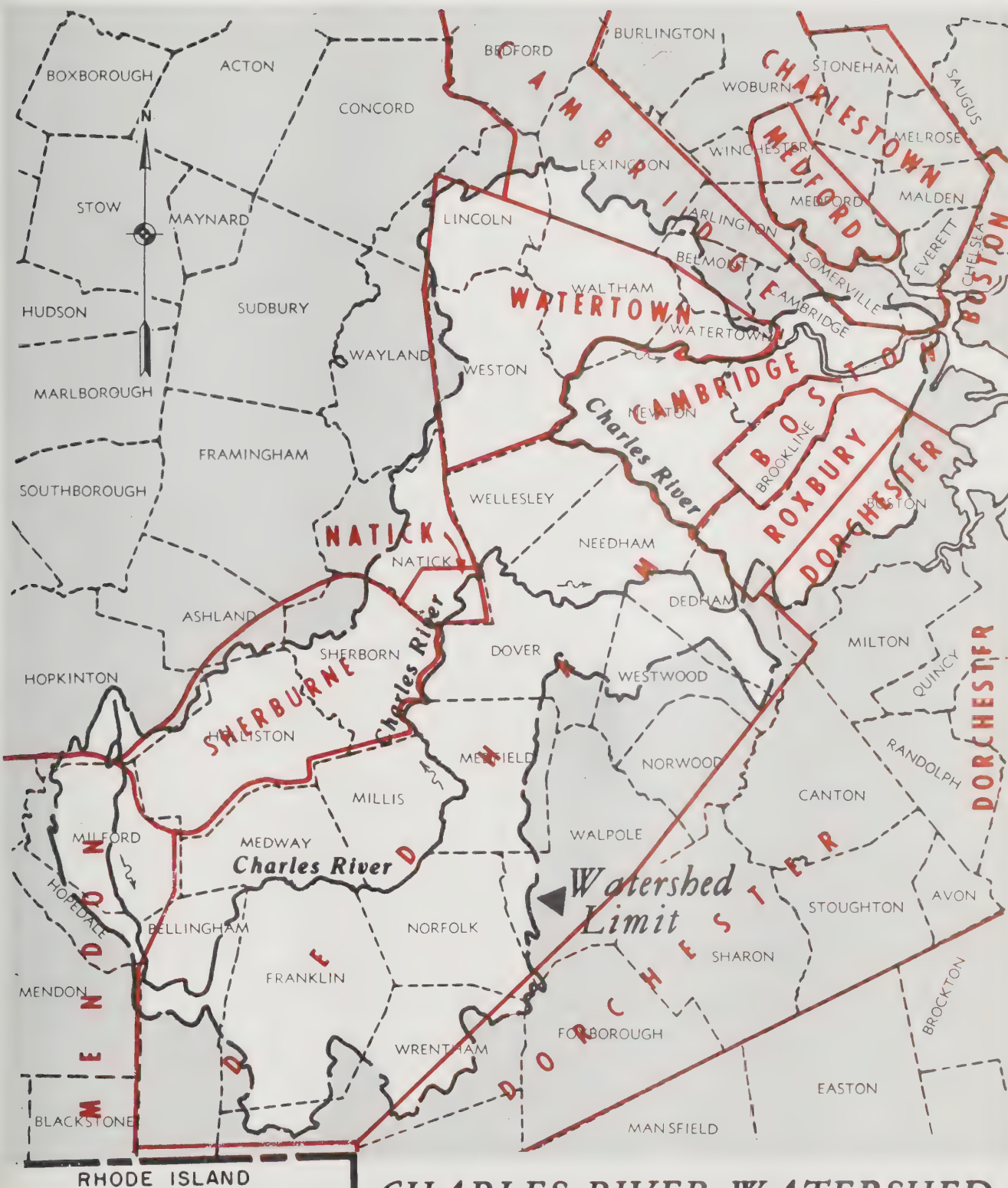
In July 1643, an alteration was voted to be made at the mouth of the Charles River. Some 50 acres of West Cove were to be dammed to create a tidal mill pond between Barton's Point and Hudson's Point, Boston, at the north end of the original Boston peninsula. That early mill pond area in 1804 was voted to be filled and became, ultimately, the site of the North (railroad) Station, and related streets, named for northern New England municipalities.

In 1794, marshes along the Charles west of Boston Common were filled in for a new ropewalk. The area so filled was voted in 1824 to become forever part of the Public Garden.

In 1795, the Beacon Hill pasture of John Hancock (who died 1793) was bought by the Town of Boston and was levelled to make a site for the State Capitol of the Commonwealth of Massachusetts, which was completed in 1798.

In 1804 and subsequently, the edge of the Charles River below West Cedar Street, Boston, was filled to make land for buildings on Charles Street and lowland environs. Much of the fill was taken from the top and the western slopes of Beacon Hill. The elevation removed varied from 30-40 feet in height to 60-70 feet, depending on the portion of the hill and the source of the statement.

After 1804, development of the old West Cove mill pond of 1643 with streets and buildings brought demand for a replacement tidal



CHARLES RIVER WATERSHED
EARLY COLONIAL TOWNS
(Cambridge Historical Society)

mill pond. Accordingly, in 1814, there was voted an authorization for a new dam west of Beacon Hill to impound water on the Roxbury Flats in the Charles River estuary, an intended impoundment of some 750 acres. This became the largest single river alteration in the Lower Charles report area.

The mill dam authorized in 1814 was completed in 1821 on the alignment now Beacon Street. The mill dam length was about 8,000 linear feet between Charles Street, Boston, on the east and on the west, the shore of Brookline, at what is now Kenmore Square. A two-pool system was created by a short cross-dam (some 900 feet length) between the northerly end of Gravelly Point, Roxbury, and the main east-westerly mill dam.

All mills were planned to be on the cross-dam. Substantially continuous water power availability was assured by automatic filling of the upper pool ("full basin," about 150 acres) twice daily at high-tide from the Charles estuary through inward flap-gates in the westerly part of the long mill-dam. Into this upper pool, there flowed also waters from the Muddy River, Brookline, and from Stony Brook, Roxbury. The lower pool ("receiving basin," some 600 acres) emptied automatically twice daily at low-tide stages to the Charles estuary through outward-opening flap-gates in the easterly part of the long dam. A modest, but sufficient water-power head was assured by the large difference in acreage of the two pools. (See plate B-2).

The Beacon Street mill dam authorization was voted 90 years before the start of the existing Charles River Dam; 50 years before the substantial filling of the Back Bay, and 20 years before any Boston area steam locomotive railroads.

Both the Boston and Worcester Railroad and the Boston and Providence Railroad (each chartered in 1831) built tracks across the "receiving basin" on the impounded Roxbury flats. The railroad embankments limited water flowage, even though the embankments were pierced by bridges and channels. And the crossing of the tracks of the two railways divided the shallows of the Back Bay into four parts. This accelerated the eventual filling of the entire area.

The first public locomotive movement across the flats, April 4, 1834, was a Boston and Worcester RR Co. gravel train. And again April 7, 1834, gravel was brought in when a party of 70 or 60 B & W RR Co. directors and friends (Nathan Hale, President) went for a (free) trial trip. The Boston Advertiser reported "They returned (from Davis's Tavern, Newton, nine miles out) in thirty-nine minutes, including a stop of about six minutes for the purpose of attaching five cars loaded with earth."

Over the fifty years 1834-1884, the whole of the formerly tidal Back Bay became filled and improved, with streets, lots, and, ultimately houses and civic buildings. (See Plate B-3).

The accompanying plates B-1, B-2 and B-3 show the changing land and water conditions along the Boston and the Cambridge shores of the Charles River, approximately as of 1814, 1836, 1881 and 1968.

In addition to the 750 acres filled in the Back Bay, there have also been filled and developed some 140 acres along the Cambridge shore, after construction of the Grand Junction Railroad (see plates), and much if not all of some 500 other acres of marsh and lowlands along both banks of the Lower Charles between Boston University Bridge, Boston, and Galen Street Bridge, Watertown. These formerly wet or marshy areas now include the Harvard Business School, much of Massachusetts Institute of Technology (M. I. T.) and many new Boston University buildings. On these filled lands are M. D. C. parks and motorways close to the River, also apartments and commercial buildings in Boston, Cambridge, Watertown, Waltham and Newton.

URBAN DEVELOPMENT

5. EXISTING URBAN STRUCTURE

Intensive urban development characterizes virtually all of the Lower Charles Report Area. Except for major public reservations, the whole of the Lower Charles Report Area is densely built-up. The major reservations are as follows:

TABLE B-1

LOWER CHARLES MAJOR RESERVATION AREAS

	<u>Approx. Acres</u>
a. MDC Charles River Reservation(Land & Water) (Leverett St., Boston-Moody St., Waltham)	1,000
b. Brookline-Boston Muddy River Park Lands (Jamaica Pond & Jamaicaway, Leverett Pond, Willow Pond) (and Back Bay Fens)	365
c. Arnold Arboretum and Bussey Institution	225
d. Franklin Park, Boston State Hospital, Ceme- teries	1,200

TABLE B-1 (Cont'd)

LOWER CHARLES MAJOR RESERVATION AREAS (Cont'd)

	Approx. Acres
Brought forward	<u>2,790</u>
e. MDC Stony Brook Reservation, West Roxbury (and George Wright Golf Course)	800
f. MDC Beaver Brook Reservation, Highland Farm and Watershed Portion McLean Hospital	220
g. North of Trapelo Road, Waltham (Middlesex County Sanatorium, Metropolitan State Hos- pital, Powder Horn Golf Course, MDC Standpipe)	765
h. South of Trapelo Road, Waltham, East of Forest Street (Fernald State School, Waltham Federal Center, Massachusetts Agriculture Experiment Station, Bentley College, City of Waltham, Park Department)	570
i. South of Trapelo Road, Waltham between Lexing- ton Street and Forest Street(Waltham) Housing Authority; City of Waltham Sr. & Jr. High Schools; YMCA, Green Acres School, Chapel Hill School, The Vale	<u>235</u>
Approximate Gross Reservation Acres	5,380
Say	8.4 sq. mi.

Although dotted with buildings, the above reserved lands (or most of them) appear likely to continue in institutional or public use throughout the next fifty years. They are not likely to become residentially developed at urban standards.

Thus of 56 square miles gross in the Lower Charles Report Area, some 8.4 square miles are major public and semi-public open spaces, and some 9.6 square miles or more are paved streets, highways, and parking lots. All the remaining 38 square miles are rather continuously and densely built up, though punctuated by school yards, church yards, cemeteries and other local green spaces. In these rather solidly built-up 38 square miles lived nearly 70% of the Watershed total population in 1965.

6. DWELLING STRUCTURE TYPES

The prevailing dwelling structure types in inner Boston and eastern Brookline are older three-story to six-story masonry apartments and town-houses, usually turned into apartments. Newer, taller, higher-density apartments are rising within sight of the Charles River and the Muddy River in Boston, Brookline and Cambridge. Older two-story to four-story single, duplex, and triplex wooden residential structures prevail throughout most of the rest of watershed Boston.

In Roxbury, Jamaica Plain and Roslindale, the structures become less and less crowded with distance out from Beacon Hill and with date of development epoch. Similar dwellings prevail in the watershed portion of Somerville, though more densely crowded.

In the Lower Charles portions of Newton, Waltham, Watertown and Waverly are mainly older, one-family and two-family wooden homes, with occasional brick apartments, appreciably less crowded than Boston.

In the small Lower Charles portions of Arlington, Belmont Hill and southern Lexington are almost exclusively newer (post 1920) one-family wooden structures at much lower densities than almost all the rest of the Lower Charles. These sharply lower densities are reinforced by the 2.8 square miles of reservations noted in items f, g, h, i, inclusive of the table of reservation areas, preceding page.

7. URBAN RENEWAL

The most deteriorated or dilapidated urban portions of the Lower Charles are in various stages of federally-aided urban renewal. Important portions of Boston, Brookline and Cambridge in the spring of 1965 were in federally-authorized urban renewal study areas and project action areas. Additional such areas had been defined in Newton and Watertown and were contemplated in Lower Charles, Waltham.

In Boston in the spring of 1965, there were ten general renewal study areas which covered about one-fourth of the City's land area and in which lived almost one-half of all Boston residents. Three of these study areas were wholly in the Lower Charles, plus about one-third of a fourth such study area, namely: Back Bay, Parker Hill-Fenway, Jamaica Plain and one-third of Roxbury-North Dorchester.

The Model City area and general renewal study areas in Lower Charles, Boston aggregated some 2,460 acres (i. e. 3.84 sq. mi.) and contained some 92,000 population. In addition, there were in the Lower Charles Report Area, portions of six other major Boston renewal project action areas, which aggregated nearly 1,450 acres additional (2.26 sq. mi.) and contained some 56,000 watershed population.

In March, 1968, there were Federal financial commitments of \$155,685,000 (capital grant and relocation grant) to the principal Lower Charles renewal project areas, as follows:

Renewal Areas	Project Acres	Lower Chas. Acres	Lower Chas. Pop'n	Est. Project Pop'n	Total Fed'l Grant	-
Boston (6)	2,285	1,450	56,100	86,900	\$122,761,000	
Cambridge (6)	243	243	10,000	10,000	26,228,000	
Brookline (2)	30	30	500	500	3,641,000	
Newton (1)	<u>69</u>	<u>69</u>	<u>1,500</u>	<u>1,500</u>	<u>3,055,000</u>	
	2,627	1,792	68,100	98,900	\$155,685,000	

8. LOWER CHARLES FUTURE URBANIZATION

Lower Charles urban development in the next thirty-three years will grow out of its 330-year evolution to date.

The forces governing its development are those influencing all of Megalopolis. For most of three centuries, this northeast coastal region has been dominant in the life of the United States, growing in size with the nation, and in many respects, leading it. The region contains one of the very large industrial belts of the world, also its greatest financial, political and educational hubs. Nowhere else have men so far created any comparable urban settlement. The influences and tendencies toward urban clustering appear likely to continue operative to the turn of the century and beyond, barring international catastrophe. No technological, economic, social or legislative developments now in sight appear likely to introduce major changes in the mode, scale or location of Lower Charles urban development.

In the first two centuries 1636-1836, before railroads and trolleys, urban concentration was a physical necessity. It was easier to cut down hills and fill shallows around the Boston peninsula, than to travel on foot or by horse between outlying villages and the center of government, trade and finance, in Boston.

In the century of railroads and the beginning of American mass use of automobiles and airlines, 1836-1936, when ten Boston area railroad commuting services were still operating, it was both easier for residents and more gainful to landowners, to spread out than to fill, except near the regional business center.

In the current century of world airlines and cessation of American railroad private passenger service, 1936-2036, there is evidently both continuing spread and re-centralization of metropolitan residents. Federally-aided urban renewal has provided one impetus; federally-aided expressway building a second; and real choking of urban areas by motor cars still a third impetus for continued clustering, and new high-rise residential, office, hospital and educational buildings.

In the Lower Charles Report Area, there are some significant local circumstances conducing toward continuing urban concentration:

a. The "unlimited" water supply afforded by MDC in the seventeen Charles River municipalities below South Natick Dam, and others;

b. The "painless" major sewage disposal likewise afforded by MDC to those seventeen communities and others;

c. The \$369 million Massachusetts Bay Transportation Authority rapid transit expansion plan of 1965, which so far involves some \$126 million Federal financial aid. The plan contemplates conversion, integration and extension of metropolitan rail commuter service. It began with a \$47 million tunnel project Boston-Charlestown, between Charles River Dam and the proposed Warren Avenue Dam. A Dorchester-South Shore extension is also under way. Cambridge-Arlington extension is scheduled to start construction in 1969. Three other extension construction designs are nearing completion.

d. A 160 mph "high-speed" train experiment, which will stop only in Boston, Providence, New Haven and New York central city stations, as now reported.

e. The desires of middle and upper Charles River property-owners to control and protect their existing low density living circumstances, plus existing limitations on water and sewerage compared to Lower Charles MDC communities.

The physical results of the foregoing influences on real estate development are rising before our eyes throughout the Lower Charles Report Area. The older prevailing two-story to six-story residential buildings are visibly being replaced by eight to twenty-story apartments, and by tightly replanned private enterprise town houses and by public housing clusters of mixed heights and types. In addition, the older prevailing six-story to twelve-story office buildings throughout the Lower Charles are being replaced by twenty-story to fifty and sixty-story buildings.

The Prudential Center affords examples of new buildings of both types. Middlesex County, M.I.T. and N.A.S.A. afford illustrations of sharply higher new public and educational classroom and research buildings. The Government Center redevelopment in Boston, outside but on the northeast edge of the Lower Charles Report Area, contains the largest cluster of new, tall public office buildings in New England.

POPULATIONS, DENSITIES, EMPLOYMENTS

9. POPULATIONS AND AREAS

The Lower Charles resident population in 1965 was some 593,700 persons, nearly 70% of the entire watershed 1965 population. In the Lower Charles report area are parts of five cities and five towns, in parts of three counties. The 1965 populations and areas of the ten municipalities between Moody Street, Waltham, and Warren Avenue, Boston, are as follows:

TABLE B-2 - POPULATIONS AND AREAS

Rounded Populations 1965			Areas(sq. mi.)		Percent of Town Area in Lower Charles
Municipality	Whole Town Pop.	Lower Charles	Lower Charles	Whole Town	
Arlington	52,480	3,000	0.3	5.58	0.54
Belmont	28,795	11,350	1.9	4.66	40.77
Boston	616,325	298,950	21.9	45.40	48.24
Brookline	53,610	49,050	4.8	6.82	70.38
Cambridge	92,675	67,350	4.6	7.14	64.42
Lexington	31,390	3,900	3.0	16.63	18.04
Newton	88,515	57,400	8.9	18.33	48.55
Somerville	86,330	28,350	1.4	4.12	33.98
Waltham	57,135	38,100	7.2	13.52	53.25
Watertown	40,115	36,250	3.6	4.17	86.33
	1,147,370	593,700	57.6	126.37	

The watershed populations listed above were estimated from state-reported populations, adjusted by 1865 and 1965 voting precincts; by counts of houses shown in April 1965 aerial photographs; and by other local knowledge.

No adjustment was attempted for local institutional or college population elements. The Federal Census enumerates each person where he is found on the Census day regardless of whether he considers that municipality his permanent domicile or not. The Decennial Census of Massachusetts counts in each municipality only those persons who claim a domicile in that or some other Massachusetts community. Hence, persons living on military reservations, students in educational institutions, and the like, are not enumerated in the State Census except in their own Massachusetts claimed municipality of permanent residence.

10. POPULATION GROWTH AND CONCENTRATION

For more than 200 years, while residents in the Lower Charles Report Area have been increasing in total numbers, the proportion of the whole Charles population resident in the Lower Charles Report Area has been strikingly constant.

TABLE B-3
EST. LOWER CHARLES POPULATION GROWTH
1765-1965
(Moody Street, Waltham; Warren Avenue, Boston)

<u>Year</u> <u>Estab.</u>	<u>Municipality</u>	<u>1765</u>	<u>1865</u>	<u>1965</u>
1807	Arlington	--	50	3,000
1859	Belmont	--	600	11,350
1630	Boston	18,400	115,700	298,050
1705	Brookline	250	4,200	49,050
1636	Cambridge	1,550	27,150	67,350
1713	Lexington	400	550	3,900
1691	Newton	1,000	7,200	57,400
1842	Somerville	--	4,700	28,350
1738	Waltham	500	5,500	38,100
1630	Watertown	500	2,850	36,250
		22,700	168,500	593,700

TABLE B-4
APPROXIMATE POPULATION DISTRIBUTION

<u>Year</u>	<u>Massachusetts</u>	<u>Entire Charles</u>	<u>Lower Charles</u>	<u>Lower Charles Percent of Entire Charles</u>
1765	240,400	33,700	22,700	67
1865	1,267,000	207,700	168,500	81
1965	5,295,300	847,500	593,700	70

The Lower Charles population of 1965 was about 26 times that of two centuries earlier, 1765. This growth was substantially in range with the population growth of the whole of Massachusetts, and was substantially equivalent to western world urban growth in the same two centuries.

It is impressive that the Charles River population distribution has continued so strongly constant, despite the great increases in numbers of residents, and despite the great changes in transportation and individual mobility during these 200 years.

In "The Historian and the City," Editors Oscar Handlin, Harvard University, and John Burchard, M.I. T., state that the largest 21 cities of the world in 1800 contained $4\frac{1}{2}$ million population. In 1961, the same 21 contained 85 million population, nearly twenty times their 1800 population. A parallel indication by Professor Charles Abrams, Columbia University, New York City, was compiled from United Nations sources in "Man and His Struggle for Shelter" and showed that cities of 20,000 population each or more around the world increased in population some twenty-three times between 1800 and 1950.

In contrast to city populations increasing twenty-times or more between 1800 and 1950, Professor Abrams reported world population in 1950 was only 2.6 times its 1800 population. For continental Europe, Professor William L. Langer, Harvard University, reported in 1963 that the population increased 2.9 times between 1750 and 1900, from about 140 million to 400 million.

The U.S. Census Bureau reports the continental United States population increased 29 times between 1800 (5,308,000) and 1950 (151,326,000). This was ten times the world and European rates of increase and reflected the emigrations from Europe, Asia and Africa into the U.S.A. during the nineteenth century, particularly into the Atlantic Coastal Megalopolis, specially Boston, New York, Philadelphia and Baltimore.

11. POPULATION DENSITIES

The Charles River Watershed axis nearly coincides with the Boston/New York/Philadelphia/Wilmington/Baltimore/Washington axis of the Megalopolis. The Charles Watershed 1965 average of 2,785 persons per gross square mile is higher than many county averages for the Megalopolis although not the New York and New Jersey peak densities, which are some of the highest in the world, table next page.

The Lower Charles Report Area average 1965 population density was 10,300 per square mile of gross area, and 12,100 or more per square mile of net area. This higher density results by deducting from 57.6 square miles gross, the 8.4 square miles of Lower Charles major reservation lands previously noted on pages B-6, B-7. Lower Charles land and water improvements will tend to benefit many Boston and Cambridge citizens who need improvement of their living conditions.

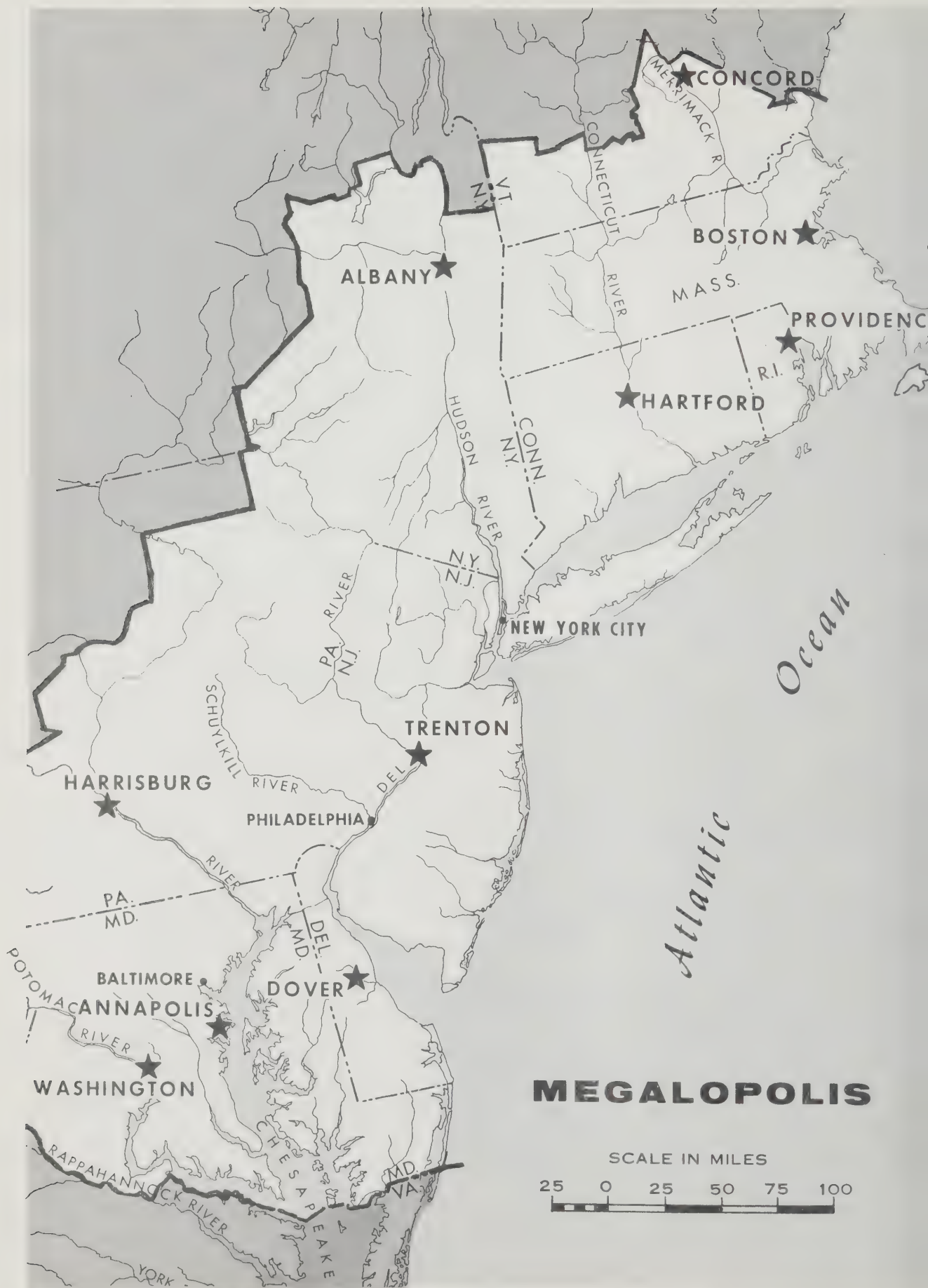


TABLE B-5

MEGALOPOLIS
1960 COUNTY AVERAGE PERSONS PER SQUARE MILE
 (U. S. Census Bureau Data)

Massachusetts

Essex	1,150
Middlesex	1,500
Norfolk	1,290
Suffolk	14,100

New York

Bronx	34,700
Kings	37,600
Nassau	4,500
New York	73,900
Queens	16,750
Richmond	3,700
Westchester	1,820

Rhode Island

Bristol	1,490
Providence	1,370

New Jersey

Bergen	3,330
Essex	7,100
Hudson	13,000
Mercer	1,170
Middlesex	1,390
Morris	559
Passaic	2,100
Union	4,890

Connecticut

New Haven	1,090
Fairfield	1,040

Pennsylvania

Camden, N. J.	1,770
Delaware, Pa.	3,010
Montgomery	1,040
Philadelphia	15,500

Maryland

Baltimore County	820
Baltimore City	12,500
(combined)	2,130

Delaware

Newcastle	700
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District of Columbia

The District	12,500
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Boston and the Lower Charles are in much the same density range as Washington, D. C., Baltimore, Md., Philadelphia, Penna., and Newark, N. J. New York City (except Queens County) is $2\frac{1}{2}$ to 5 times the population density of Suffolk County and the Lower Charles Report Area.

TABLE B-6

LOWER CHARLES 1965 POPULATION DENSITIES

<u>Year</u> <u>Estab.</u>	<u>Municipality</u>	<u>Watershed</u> <u>Portion</u> <u>Sq. Miles</u>	<u>Watershed</u> <u>1965</u> <u>Est. Pop'n.</u>	<u>Average Residents</u> <u>per square mile of</u> <u>Watershed</u>
1807	Arlington	0.3	3,000	10,000
1859	Belmont	1.9	11,350	6,000
1630	Boston	21.9	298,950	13,650
1705	Brookline	4.8	49,050	10,200
1636	Cambridge	4.6	67,350	14,650
1713	Lexington	3.0	3,900	1,300
1691	Newton	8.9	57,400	6,450
1842	Somerville	1.4	28,350	20,250
1738	Waltham	7.2	38,100	5,300
1630	Watertown	<u>3.6</u>	<u>36,250</u>	<u>10,100</u>
TOTALS		57.6	593,700	10,300 gross

The overall population density of Lower Charles Boston rises from 13,650 (above) to 18,450 after deducting the following four unusually large open-space clusters which serve metropolitan needs and demands:

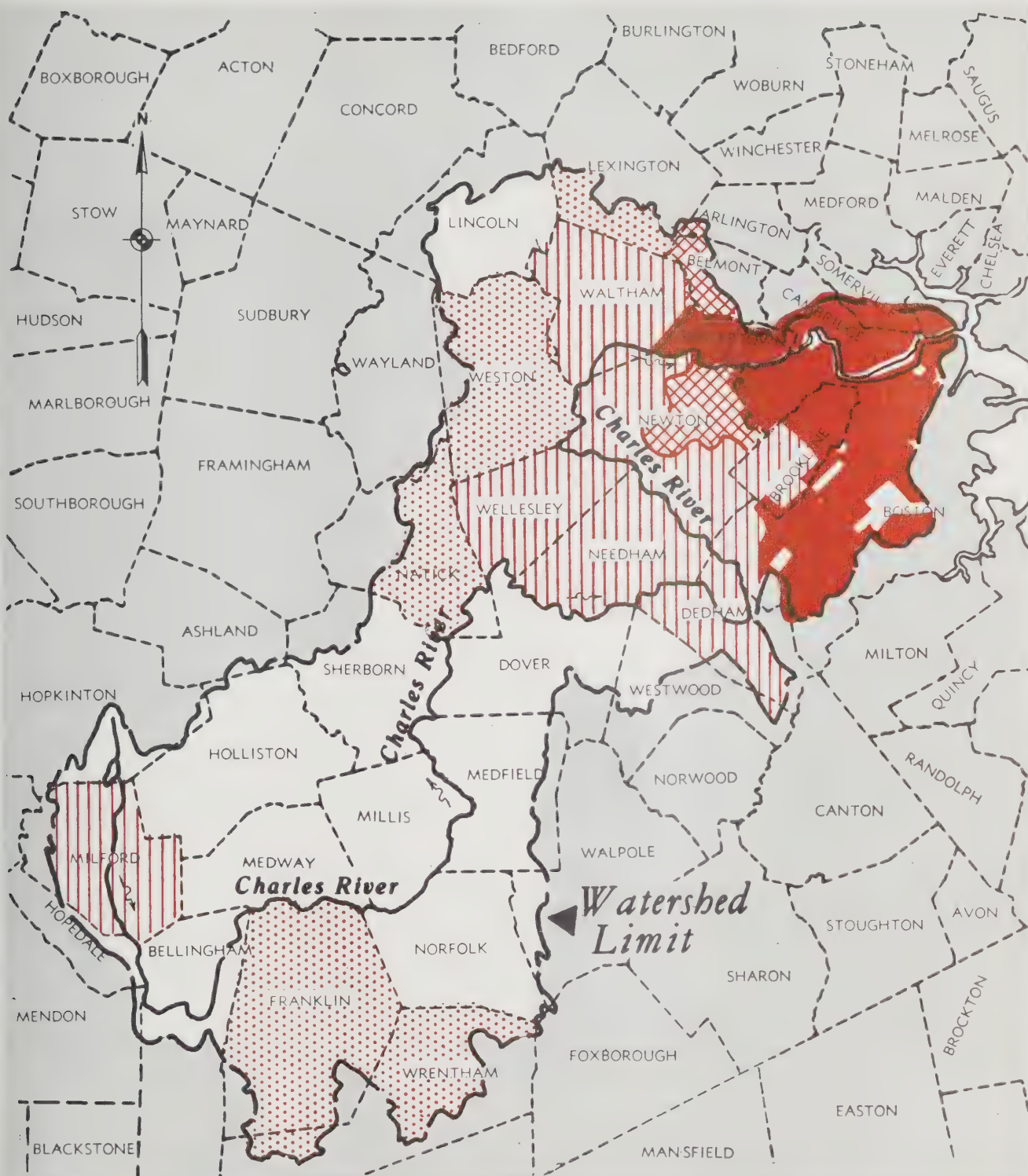
(a) Boston Common, Public Garden and the Boston portion of the 1800-acre MDC Charles River Reservations;

(b) Franklin Park, Franklin Field, Forest Hills Cemetery, Mt. Hope Cemetery, St. Michael's Cemetery, Calvary and New Calvary Cemeteries, and Boston State Hospital Grounds -- together about 1200 acres between Seaver Street and Cummins Highway;

(c) MDC Stony Brook Reservation plus Wright Golf Course, in West Roxbury, Washington Street southeast of Mt. Bellevue, together about 780 acres;

(d) In West Roxbury, the great cluster of cemeteries and Boston city dump between VFW Parkway and the Boston/Newton boundary, together about 770 acres.

The above four Boston open-space clusters aggregate some 5.7 square miles, which is more than 25% of the Lower Charles total 21.9 square miles of land and water area within Boston.



CHARLES RIVER WATERSHED 1965 AVERAGED RESIDENTIAL DENSITIES



(Approx. persons per gross square mile)

Boston average building density per square mile is as high, or higher, than that of any other Lower Charles municipality. Boston average resident population density also is the highest in the watershed, by a small margin, when predominantly residential land uses are examined. The density is 20,590 in Roxbury and Jamaica Plain, in the 2.65 square miles between Roxbury Crossing, the Harvard Medical School and the Jamaica-way and Arborway, Wards 10, 11, and the upper part of Ward 19. The density is 18,400 in 3.07 square miles in Brighton, between but excluding Chestnut Hill Reservoir, Boston University Field and Harvard Stadium (Soldiers Field), Wards 21 and 22.

The Boston West End Renewal Project Area looks out onto the Charles River Dam and Science Museum. The actual residential project density may be between 75,000 and 100,000 persons per square mile for the 47 acres gross project area or the 38 acres after subtracting 8-2/3 non-residential project acres.

In the 47 gross acre project area, there will be a total of 2,400-2,500 apartment and town-house dwellings on completion. The 1967 occupancy of the 1,500 units so far constructed appears to range 2.5 to 2.2 persons per dwelling unit. 2.2 persons per unit, at 53 units per gross acre equals 75,000 persons per square mile. After deducting 8.67 non-residential acres, the project density in the remaining 38 acres rises to 66 units/acre or 93,000 persons per square mile, a density ranking with the highest density ranges in any of the great cities of the western world.

An average density of only 10,200 is shown for the Lower Charles portion of Brookline. However, 48,630 of these 49,050 residents in 1965 were living in the eastern 3.8 square miles of the Lower Charles portion of Brookline, east of the Country Club and major estate sections of Brookline. Accordingly, 12,800 average density more closely represents eastern Brookline and lower Muddy River watershed conditions.

Future Water-Related Land Use Demand

The Charles River Park buildings in Boston, close to the Charles River, also the newest Harvard, M.I.T., Boston University, Prudential Center, and water side of Beacon Street new buildings, demonstrate the very great increase in population and in water and sewer demands and in demand for water-related land spaces that is taking place in the Lower Charles parts of Boston and Cambridge.

12. FUTURE POPULATION AND CONCENTRATION

High intensity urbanization has long marked the Charles. Four-sixths of all Charles residents in 1965 lived in one-sixth of the Watershed, the Lower Charles Report Area. Two centuries ago, in 1765, about the same proportion also were living in the Lower Charles Area. Continuing concentration in the Lower Charles appears likely.

For near future Lower Charles population prediction, regional migration appears likely to be the dominant factor, not cohort survival and not fertility nor demographic sex and age-group factors. Many Lower Charles institutions are of national or of regional character and significance. Such institutions will not soon be duplicated, nor be relocated elsewhere than the Lower Charles. So far as they are the work-places of local residents, these primary economic institutions and all related secondary and tertiary activities will continue to draw and hold large numbers of persons in the existing stock of acceptable dwellings nearby.

Federally-aided urban renewal in portions of Boston, Brookline, Cambridge, Newton, Watertown and Waltham are replacing or enhancing portions of that existing dwelling stock. Federal, State and Municipal taxation policies, together with great fixed public and private investments in parks, water supply, sewerage, airport, seaport, motorways, rapid transit, and major health, and education institutions have established a framework for private property developments of the future in metropolitan Boston. New apartments, office buildings, classrooms and dormitories are being built throughout the Lower Charles. Harvard, M.I.T. and B.U. buildings and the Prudential Center are large recent examples. New high-rise apartments on the Muddy River at Brookline Village are approaching completion. A John Hancock Insurance Company building is proposed in the Back Bay, taller than the Prudential. Financing is announced for developments in Newton and Watertown of clusters of high-rise apartments, high-rise offices, and a hotel not far from the Charles River. The twelve-story N.A.S.A. building in Kendall Square and a new multi-story Middlesex County office building in East Cambridge are in construction. The Town of Watertown desires taxable re-use of former Watertown U.S. Arsenal property. Farther upstream on the Lower Charles in Watertown and Waltham, there have been additional new buildings and groups of buildings with parking areas for stores and for industry.

Taken together, these developments demonstrate a likelihood of continuing population concentration in the Lower Charles Study Area. On that assumption, a trial forecast to the year 2000 could be constructed as follows:

(1) A U.S. National population of 200,000,000 was declared by the U.S. Department of Commerce in November 1967, and was said to be about 70% urban.

(2) A 300,000,000 population by the year 2000 has been federally forecast, expected to be about 80% urban. The increase is 50% of the 1967 population. Spread over the next 33 years, 50% growth would result from 1.25% average annual increase.

(3) The Charles Watershed population in 1965 was about 847,500 people, about 90% urban and sub-urban. The Watershed growth 1865-1965 was nearly 640,000 persons, an annual average increase of about 1.13%.

(4) It is presumed the Lower Charles growth will parallel the national and megalopolis urban growth through the next thirty-three years. In the century 1765-1865, the Lower Charles grew at an average annual increase of 1.875% and from 1865-1965, at an annual average of 0.9375%. The 150 county Atlantic Urban Region called Megalopolis in this report grew at an annual average rate of 1.42% between 1860 and 1960, per New York Regional Plan Association, Inc., data.

(5) A 50% increase at the year 2000 of the entire Charles Watershed 1965 population would result from annual average population growth at 1.16% in the 35 years 1965 - 2000, but distributed by geographic segments as follows:

TABLE B-7 - POPULATION PROJECTIONS

<u>Segment</u>	<u>Year</u> <u>1965</u>	<u>Pop'n</u> <u>Growth</u>	<u>Year</u> <u>2000</u>	<u>1965-2000</u> <u>Population</u> <u>Increase</u>	<u>Ann.</u> <u>Avg.</u> <u>Incr.</u>
Lower Charles (Warren Ave., Boston-Moody Street, Waltham)	593,700	260,000	850,000	44%	1.031%
Mid-Charles(Moody St. Waltham-South Natick Dam)	177,000	73,000	250,000	41%	1.000%
Upper Charles (So. Natick Dam to sources)	<u>83,000</u> 850,000	92,000	<u>175,000</u> 1,275,000	111%	<u>2.187%</u> 1.161%

The overall result is a 50% increase in Watershed total population, with two-thirds of the total still living in the Lower Charles, the same relative distribution and concentration as 1965.

Whatever the specific numbers, it may be responsibly speculated that about two-thirds of the future residents of the Charles Watershed will continue to live in the Lower Charles Report Area because of the huge concentration of metropolitan utilities and facilities already installed there, and because these facilities and others to come are unlikely soon to be duplicated or removed.

The foregoing 35-year trial forecast of Lower Charles population growth is based principally on expectation of continuing Lower Charles concentration of offices and apartments, the building of both of which appears to have been accelerating since 1960 in Boston, Brookline and Cambridge. Also, the 35-year 260,000 person Lower Charles population growth is 61% of the 100-year Lower Charles overall population growth 1865-1965.

In the Upper Charles, population doubling or a little more by the year 2000 appears likely, in view of open land availability. However, if the existing lack of metropolitan sewerage and the existing water supply deficit above South Natick Dam continue, home building in the Upper Charles will be in some degree deferred or inhibited.

Accordingly, barring national catastrophe, there appears reason to expect continuing concentration of residents and of week-day commuters in the Lower Charles Report area. The prospect of such continuing concentration has several consequences for the Lower Charles Interim Report on flood control and navigation.

First, floods of the future, equalling Charles Basin water levels of August 1955, could cause greater loss, damage, disruption and inconvenience than in 1955 because of further concentration of buildings and transportation facilities in the Basin lowlands.

Second, the physical bulk of buildings in the lowlands close to the Basin is increasing and the occupancy is changing from being formerly nearly exclusively residential toward being mixed residential, institutional and commercial. The basements tend to be deeper, with more machinery.

Third, recreational demands on Charles River Basin water surface and related open river-bank or river-view lands will rise with the rising buildings and rising population in the Lower Charles Report Area.

Thus, it appears likely that future population growth will increase the need for control of pollution, control of flooding, and added navigational facilities, in the Lower Charles Report Area.

EMPLOYMENTS

13. "COVERED" AND NON-COVERED JOBS

The Lower Charles is a regional job center of importance, and a center mainly of non-manufacturing jobs. Nearly three-quarters of all September 1965 Lower Charles "covered" jobs were non-manufacturing, and only 27% were in manufacturing, as then classified.

One-third of all jobs in Massachusetts covered by employment security in September 1965 were in the nine Lower Charles municipalities reported on the next page, including one-fifth of all manufacturing jobs, one-third of all retail jobs, two-fifths of all service jobs, virtually half of all wholesale jobs, and nearly 60% of all jobs in finance, insurance and real estate in the Commonwealth.

The data presented were selected, compiled and rounded to nearest "0" or "5" from individual city and town data tabulated by the Massachusetts Division of Employment Security by months for the calendar year 1965. These data are necessarily for the whole of each municipality. There was no practical way to identify employments in only the watershed part of each municipality. Also, many watershed residents may work at employments outside but near the watershed. It was determined to compile data for only those municipalities 20% or more by geographic area within the watershed. As a result, in the Lower Charles Interim Report Area nine municipalities are reported; Arlington is excluded.

Comparison of 1965 overall employments in U.S.A., Massachusetts, Boston SMSA, and the nine Lower Charles municipalities emphasizes the economic roles of the Lower Charles as a center of "service" employments -- government, trade and distribution, finance, insurance, real estate, transportation, communication, charitable and non-profit activities, including health, social services and higher education. 73.34% of total employments ("covered" plus non-covered) were in the foregoing secondary and tertiary "service" groups of employments, while only 26.66% were in manufacturing, contract construction, and agriculture, mining, forestry and fishing.

The finance and insurance activities are of national and of regional importance.

TABLE B-8

SELECTED LOWER CHARLES COVERED JOBS

MONTH OF SEPTEMBER 1965 (ROUNDED)
 Massachusetts Division of Employment Security
 Employment & Wages for the Year 1965
 Issued July 1966

<u>Municipality</u>	<u>Aggreg't Covered</u>	<u>Mfg. Jobs</u>	<u>Finance</u>		<u>Wholesale Jobs</u>	<u>Service Jobs</u>
			<u>Retail Jobs</u>	<u>Insurance Real Est.</u>		
Belmont	3,210	215	1,295	215	250	620
Boston	361,590	77,230	71,510	56,705	41,900	58,710
Brookline	10,670	430	3,840	1,540	830	2,855
Cambridge	61,385	23,830	9,685	1,775	6,560	7,645
Lexington	3,965	565	910	170	30	1,550
Newton	23,825	8,435	5,300	905	1,785	4,570
Somerville	16,845	4,230	5,540	465	1,550	2,205
Waltham	31,520	18,010	5,025	920	1,975	3,170
Watertown	17,260	10,300	1,575	325	1,585	1,170
LOWER CHARLES TOTALS	530,270	143,245	104,680	63,020	56,565	82,495
ENTIRE CHARLES 27-Town Totals	577,398	161,263	116,129	64,953	60,441	87,178
COMM. of MASS.	1,601,105	674,200	320,750	105,300	102,477	191,900
LOWER CHARLES % of Massachusetts	33.11%	21.24%	32.63%	59.84%	55.20%	42.99%

The national importance of Lower Charles finance and insurance activities is both in sheer money and credit concentration, in which Boston is one of the four or five ranking centers in the United States of America, and in the prudence, character, integrity, innovative and keenly competitive Boston flair for management in finance and insurance. During 150 years or more, the Boston area has been a leader in these respects.

An early example was "mutual" life insurance; another, the Massachusetts real estate trust; another, Massachusetts "mutual" savings banks; still another, the Massachusetts savings bank life insurance; a more recent example, the Massachusetts public, diversified investment trust; a most recent example, the banking certificate of deposit. A Boston area post-depression innovation was the new-process (or new product) risk-capital trust or corporation.

The regional importance of Boston area finance and insurance activities is in the growing employments made possible by financial managerial capability and creativity, and by the availability for loans to local enterprises of the Boston-managed pools of capital.

The economic importance in the Lower Charles area of the availability of finance and insurance capital and management is made evident by contrasting the Lower Charles River economy and urban development with those of the Lower Connecticut River and of the Lower Merrimack River, comparing only the 12 to 15 miles of each river nearest the mouth.

14. HIGHER EDUCATION

The Charles River Watershed graduate schools, colleges, institutes, libraries, museums, laboratories, teaching hospitals, research corporations, and affiliated or ancillary facilities, together constitute a compact cluster of national and international importance. There is no other cluster directly comparable as to size, variety and academic excellence in so small a geographic compass.

Total college enrollments in the Charles River Watershed are nearly five times the national average, and more than four times the New England average enrollment per thousand resident population. College student enrollments were some 142 per thousand in the Watershed, $37\frac{1}{2}$ in Massachusetts, nearly 33 average in New England, and only 29 per thousand U.S.A. population in 1965.

Of 224 degree-granting collegiate institutions in New England, 105 are in Massachusetts, 49 are in the Watershed, and 42 in the Lower Charles, clustered close to one another in Boston, Brookline, Cambridge, Chestnut Hill and Watertown. These 42 institutions in September 1966, together enrolled 110,600 students, and employed 9,100 administrative and faculty full-time personnel.

Fifteen of the 42 Lower Charles institutions in 1966 enrolled 1,000 or more students each, tabulated below:

HIGHER EDUCATION INSTITUTIONS
ENROLLING 1,000 STUDENTS EACH, OR MORE, IN 1966
DOWNSTREAM OF MOODY STREET, WALTHAM

<u>Boston</u>	<u>Enrollment</u>
State College at Boston	3,723
University of Mass. (Boston only)	2,151
Bentley College	1,961
Boston University	18,163
Emerson College	1,072
Emmanuel College	1,367
Northeastern University	31,737
Simmons College	2,067
Suffolk University	2,662
Wentworth Institute	2,241
 <u>Cambridge</u>	
Harvard University	13,564
Radcliffe College	1,215
Mass. Institute of Technology	7,567
 <u>Chestnut Hill</u>	
Boston College	8,578
 <u>Watertown</u>	
Mass. Bay Community College	<u>1,222</u>
	99,290

In higher education, Boston and Cambridge are the center of the Lower Charles and of New England, with more than 99,000 students enrolled in collegiate institutions of 1,000 each or more. Continuance and enlargement of these enrollments are to be **expected** throughout coming centuries, and continuance of their faculty and other full-time jobs in Lower Charles Report Area.

15. FUTURE JOB TRENDS

During the past 100 years, gainful employments in the United States of America have changed from very largely individual activities, many out-of-doors, to largely group operations, mostly in-doors, and often within arm's length. That change, and the accompanying industrialization and urbanization, have been less noticeable in New England and the Lower Charles than elsewhere, because of its own early urban, industrial and mercantile development. These social trends appear likely to continue operative and to favor further urban concentration in the next half century.

Two counter-influences are coming into view. One is computer-impelled change in mercantile distribution; in health, education and welfare services; in finance and banking; in research, and in professional services. The other is the great change in business and governmental communication, coming via TV, telephone and COMSAT. These counter-influences may make possible some dispersal of home and of office concentrations, but mainly within and related to the great urban regions, not--in any large numbers -- far away from the metropolitan clusters.

In the past 35 years of war and depression (1930-1965), most of the former eastern Massachusetts shoe manufacturing and textile weaving, finishing and converting employments ceased in the Charles and the Lower Charles, particularly in Newton, Waltham and Watertown. Succeeding them are large new employments in electronics, cameras and film, instrumentation, office machines, and publishing; also growing employment in finance, insurance and real estate, in higher education, in government, in other health and education facilities and programs, in welfare, and in other services.

In the coming 35 years, (1965-2000), continuation of the recent trend is anticipated. Continuing declines of Lower Charles employments in agriculture, textiles, leather and primary metals are expected. Gains in manufacturing employments are expected in paper converting and publishing, in chemicals, apparel, fabricated metals, and machinery, both

electrical and non-electrical, and in mechanical rubber goods. This employment forecast is illustrated by two separate 1968 private enterprise proposals: one, for a printing plant, the other for a light metal fabricating plant, to be established in Roxbury.

Output per man hour in manufacturing has been steadily rising 3% per year or more in U.S.A. since 1945, according to the U.S. Department of Labor. By 1970, it has been stated, a worker will produce twice the amount of goods each hour that his counterpart did in 1945.

The Lower Charles economy, however, is more likely to grow at high levels of employment and income by interactions in the Boston area of the existing finance and insurance enterprises and the existing institutions of higher education, than by expansion of manufacturing employment. Two other large Lower Charles employments not mentioned above are those in health services and in government.

Some 158,000 persons were employed in 1965 in all levels of government in the Boston Standard Metropolitan Statistical Area: 38,000 Federal, and 120,000 state, county and municipal. Some large fraction of the 158,000 -- two thirds or more -- are estimated to be government employed at locations in the Lower Charles Report Area.

The Greater Boston Hospital Council, Inc., in its 1967 Guide listed 53 general hospitals, of which 33 were in the Charles and 29 in the Lower Charles. These 29 general hospitals reported an aggregate of 7,479 beds and 19,333 staff personnel (not counting doctors).

Both of these forms of employment also are more likely to grow than to decline in the Lower Charles Interim Report Area.

Thus, all the major employments in the Lower Charles future economy appear likely to continue predominantly non-manufacturing, non-farming, and non-extractive.

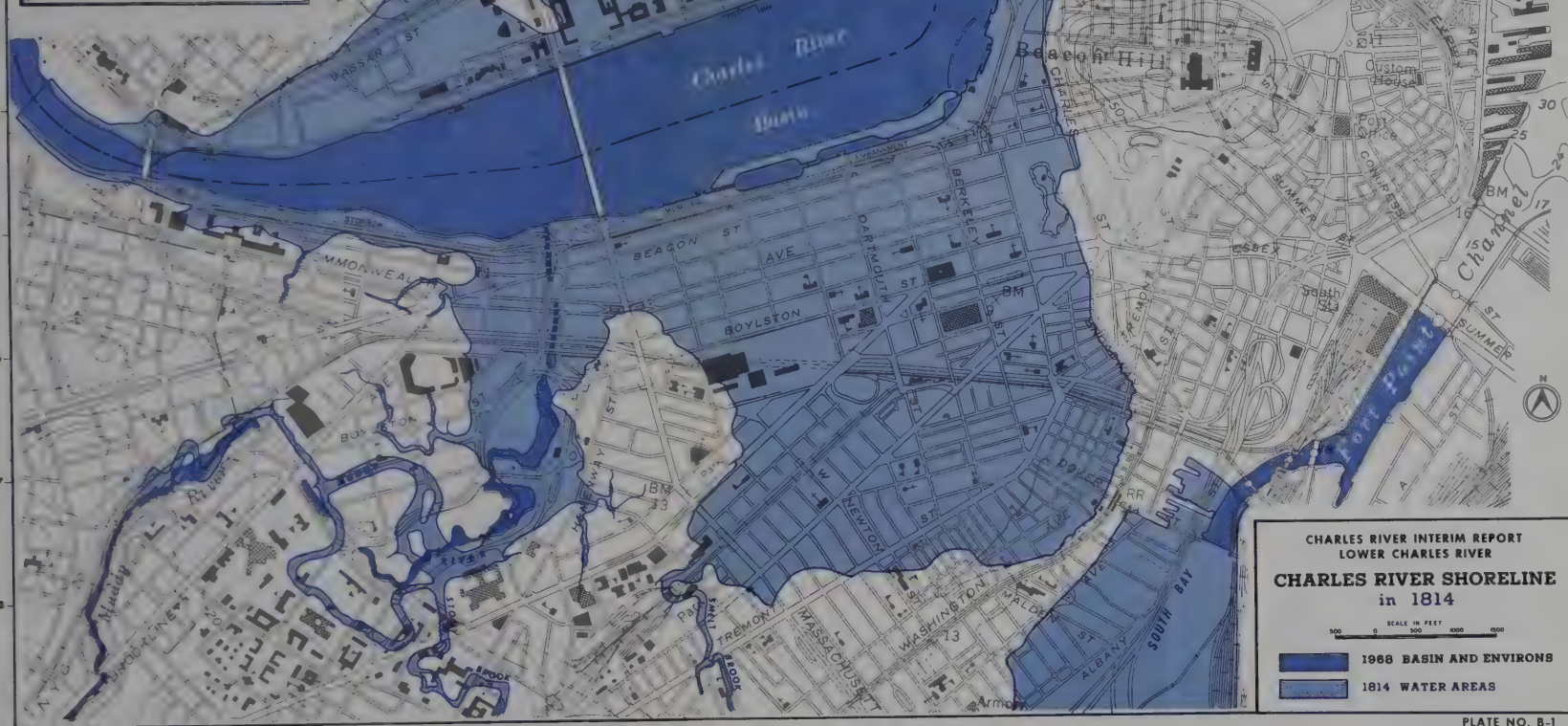
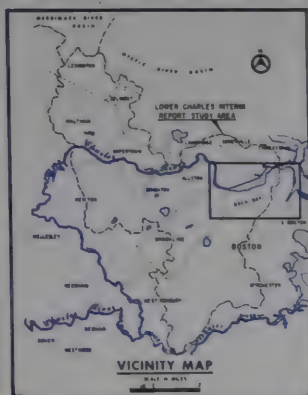
16. CONCLUDING SUMMARY

In the Lower Charles, as in the nation, the majority of the labor force produces or performs services, and does not produce large volumes of manufactured goods, except of a high value-added nature.

Continuing economic job opportunities in the Lower Charles, also improvement of Charles River recreation facilities (both land and water) and reduction of pollution in the main river, will continue to draw residents from elsewhere into the Lower Charles.

Some \$500 million or more federally-assisted major public improvements are committed or recently completed in the Lower Charles Report Area. These include more than \$150 million federal financial aid in Boston, Brookline and Cambridge urban renewal; some \$125 million rapid transit extension assistance; some \$125 million Central Artery, Inner Belt and I-95 Canton-Boston assistance; and some \$110 million North Charles, South Charles and other sewage overflow elimination measures.

With some \$500 million federal participation in these improvements and others either committed or under way, it would appear prudent to contemplate some 3% additional outlay in order to prevent future flooding, if possible, in the Charles River Basin and adjoining lowland properties, utilities, buildings, and motorways that could be protected.



CHARLES RIVER INTERIM REPORT
LOWER CHARLES RIVER
**CHARLES RIVER SHORELINE
in 1814**

SCALE IN FEET
500 0 500 1000 1500

- 1968 BASIN AND ENVIRONS
- 1814 WATER AREAS



SCALE IN FEET

1968 BASIN AND ENVIRONS

1836 WATER AREAS



APPENDIX C

GEOLOGY

APPENDIX C
GEOLOGY
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APPENDIX C

GEOLOGY

GENERAL GEOLOGY

1. The Charles River is a perfectly normal consequent stream (Plate C-1). It has a fall of less than three hundred feet and a well-developed meander pattern having an average amplitude of about four miles and an average frequency of about six miles. The stream, therefore, traverses about 80 miles of territory to cross a straight line distance of less than 30 miles. The course of the Charles River is governed only in a very broad sense by the underlying rocks (Plate C-3); i. e. the rock-fault basin of Boston is the basic reason for the existence of a stream flowing northeast from the southwest quadrant of that region as one arm of a radial drainage pattern. The short length of the river is attributed also in a very general way to the nature of the surrounding hardrock territory which is an old eroded surface essentially planed off. The irregular old hardrock surface, its depressions glutted with glacial debris, is not conducive to the development of long, free-flowing streams.

The short stream of the Charles River, however, has been able to achieve quick maturity because it lies mostly on unconsolidated glacio-marine and outwash sediments, with only its upper reaches on the more resistant glacial till and bedrock upland. Surficial materials have influenced the course of the river, strikingly evident on Plate C-2, with resistant till and rock hills serving as points of deflection which have influenced the development of meanders.

BEDROCK

2. The Charles River watershed is situated over and partly on bedrock formations which range in age from pre-Paleozoic to Mesozoic. The upper tributary areas generally lie on older formations and the lower reaches of the watershed, where streams are largely at base level, overlie younger rock formations (Upper Paleozoic). The youngest formations (Mesozoic) are trap dikes which were intruded into the other formations. The lower elevations of the younger rock formations with respect to the older rock formations are accounted for because the rocks lie in a structural basin, a rude fan structure complicated by faults. Regional erosion which extended through long periods of geologic time removed astronomical quantities of younger rocks and it was generally only by being depressed in such down-faulted basins that rocks as recent as those of the Upper

Paleozoic have survived. Now, the younger rocks are highly indurated, but in the distant past they were relatively less resistant to erosion than the surrounding older rocks because the latter, although largely sedimentary in origin, had undergone previous cycles of magmatic injection and intrusion. The younger rocks, therefore, underlie a topographic lowland, relatively speaking, and they are less contorted and metamorphosed than are the surrounding older rocks which have endured more disturbance of the earth's crust. The outline of the Boston Basin, whose rocks are folded conglomerates, mudstones and volcanic rocks, trends northeasterly to easterly, locally east-southeasterly, as do the folds in the rocks which pitch in an easterly direction. The situation suggests that the structural basin feature extends beneath the Gulf of Maine, hence it may be associated with major coastal dislocation.

OVERBURDEN

3. Most of the Charles River and its tributaries are carved into glacial overburden which is essentially the only material overlying bedrock inasmuch as residual soils were removed by intensive Pleistocene glaciation. There have been attempts to correlate the course of the present Charles River with preglacial ancestral streams and there is minor supporting evidence of troughs in the bedrock surface, but it is known that the underlying rock surface is highly uneven and such theories are merely inferential at best. The overburden deposited by glaciation set the stage for new consequent drainage patterns, generally dendritic in character. The bedrock depression of the Boston Basin enabled marine invasion during the Pleistocene glacial epoch thereby permitting the deposition of the "Boston Blue Clay" fine materials which attain thicknesses of well over a hundred feet and are famous for presenting building foundation problems. The silts and clays are encountered several feet below sea level wherever a depression of sufficient depth has a connection to the sea. Outwash deposits flank bedrock-controlled hills of some of the various anticlinal folds of the basin and near the basin rim but the predominant overburden in the basin is a dense glacial till which was plastered on the eroded rock hummocks and ridges. Many of these till-covered hills were streamlined by glacial movement and shaped like inverted teaspoons, and are famous as the drumlins which dot Boston Harbor and afford it its natural protection from the sea. The till is very compact, hence best foundation conditions are found on the hills. The till also exists in varying thicknesses, but is generally fairly thin, beneath the blue clay. It covers the bedrock

surface and thereby establishes the age of the fine sediments as late glacial or inter-glacial in age. Recent deposits are primarily marsh materials and harbor mud. They have played a major role in the history of Boston and particularly in that of the lower Charles River watershed (Plate C-4).

SEDIMENTATION

4. Sedimentation in the Charles River watershed can be estimated in terms of Korbels formula for solid suspension load, based on the size of the watershed and on other factors. It is necessary, however, in an area as highly developed as this to correct for anthropogenous erosion. Man-made land forms are not directly comparable with natural land forms which have been developed over long geological periods. Korbels formula yields for the Charles River watershed a solid suspension load of approximately 8,000 tons/year. Most of this material should settle in the basin. This figure probably should be augmented by correcting for anthropogenous erosion. It is doubtful, however, that it would be increased sufficiently to account for an approximate one and one-half million tons of material which appear to have accreted in the basin below Cottage Farm during the last sixty-five years. Anthropogenous activity appears to account for two-thirds and nature for one-third of the materials accumulated behind the dam. The accumulation of material behind the dam has not had any adverse effect thus far because about two and one-half million tons have been removed during the same period, largely for construction purposes of embankment highways. It is reasonable to assume, however, that natural sediment will continue to collect in the basin at a rate somewhat in excess of eight thousand tons per year with fairly even distribution of materials. This will amount to nearly another half-million tons of shoaling and, if anthropogenous sedimentation continues at twice the rate of the natural shoaling, the volume of the basin will be greatly reduced by the year 2020.

MINERAL RESOURCES

5. The principal mineral resources of the lower basin are sand, gravel, crushed stone and water. They are not seen to play an important role in the future economic development of the watershed area because they have been largely depleted and are giving way to urban sprawl. Natural construction materials already are being imported into the Boston area from sources as remote as New Hampshire.

DAMSITE FOUNDATIONS

6. Geologic sections of the two principal sites considered for the Charles River Basin Elevation Control Project are shown on Plate C-5. The Warren Avenue Bridge site offers shallower foundations on overburden, while the upstream site, just below the existing dam, would require a deep pile foundation.

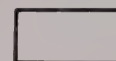
GROUNDWATER

7. Groundwater elevations were stabilized at about nine feet above mean low water by construction of the original Charles River Dam. The raising of groundwater elevations above a new dam should not adversely affect old structures in the area, many of which are founded on timber piles, whereas if the water levels continue to fluctuate, the tops of the piles will continue to rot. The new structure should tend to stabilize foundation conditions locally by establishing a uniform high groundwater level.

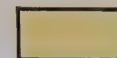


LEGEND

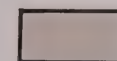
Elevation in feet above M.S.L.



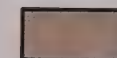
100 and under



100 - 200



200 - 300



300 and over

**CHARLES RIVER INTERIM REPORT
GENERAL RELIEF MAP
OF
CHARLES RIVER WATERSHED**

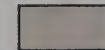
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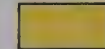
LEGEND



WATER AREA



TILL OVERLYING BEDROCK



SAND AND GRAVEL



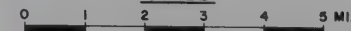
SILT, SAND, CLAY, AND ORGANIC MATERIAL

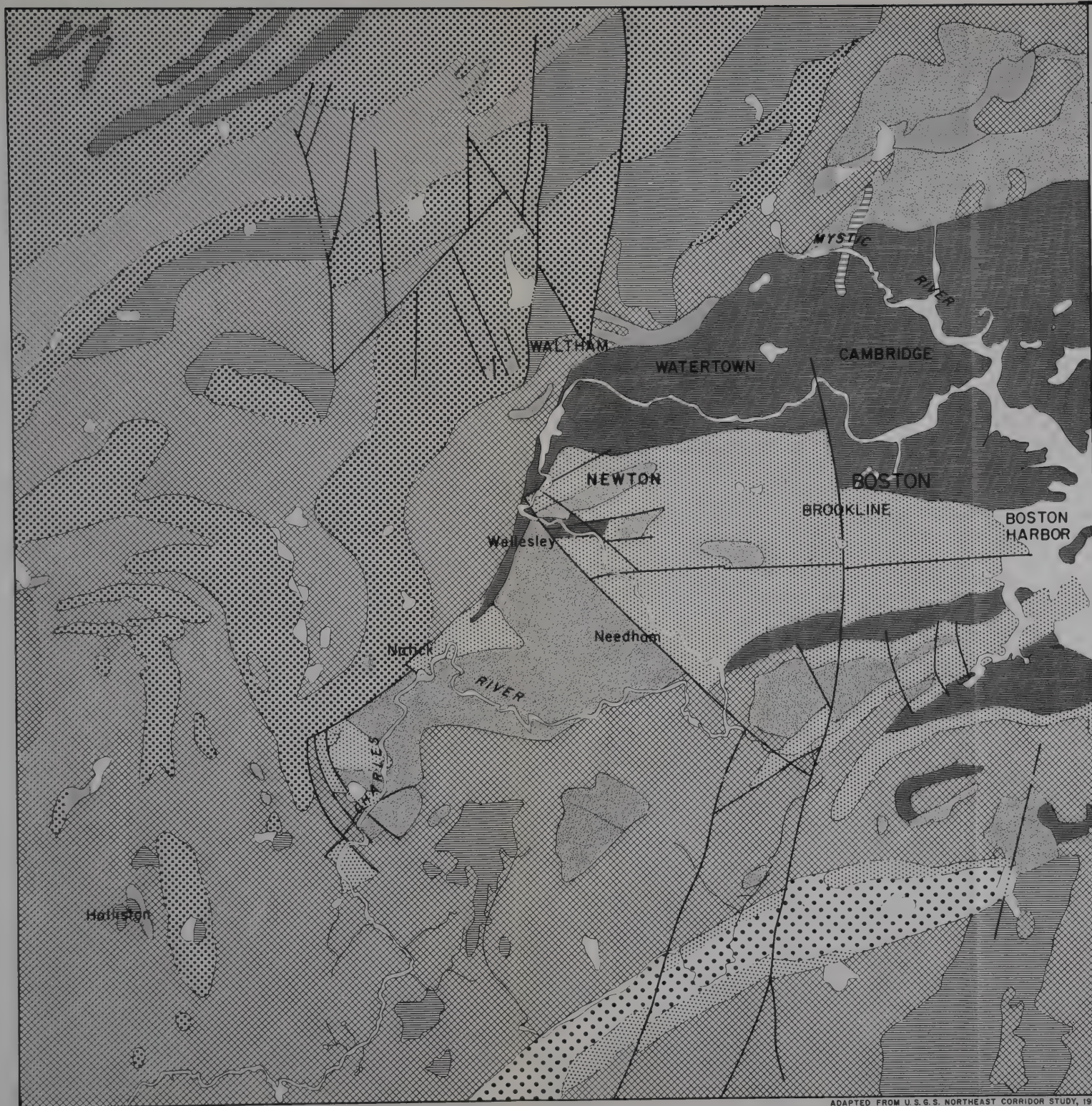


SILT OR CLAY WITHIN OR BENEATH PERMEABLE
SURFICIAL DEPOSITS




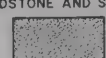

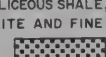
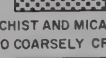


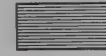
CHARLES RIVER INTERIM REPORT SURFICIAL GEOLOGY OF CHARLES RIVER WATERSHED

SCALE





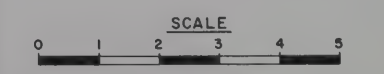
LEGEND

-  BASALT FLOWS, DIABASE DIKES AND SILLS
-  CONGLOMERATE
-  SANDSTONE AND SHALE
-  VOLCANIC ROCKS
-  ARGILLITE, SILICEOUS SHALE, SLATY SHALE, SLATE, PHYLLITE AND FINE GRAINED SHIST
-  MICA SCHIST AND MICA GNEISS, MEDIUM TO COARSELY CRYSTALLINE
-  QUARTZITE, WITH INTERBEDDED CONGLOMERATE, SCHIST, AND GNEISS
-  MASSIVE TO GNEISSIC GRANITIC ROCKS
-  QUARTZ GABBRO, DIORITE, DARK QUARTZ DIORITE, AND THEIR LOW-GRADE METAMORPHIC EQUIVALENTS
-  AMPHIBOLITE, EPIDOTE AMPHIBOLITE, AND WELL-FOLIATED METAGABBRO

CONTACT

FAULT




**CHARLES RIVER INTERIM REPORT
BEDROCK GEOLOGY
OF
CHARLES RIVER WATERSHED**





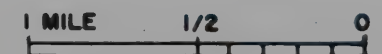


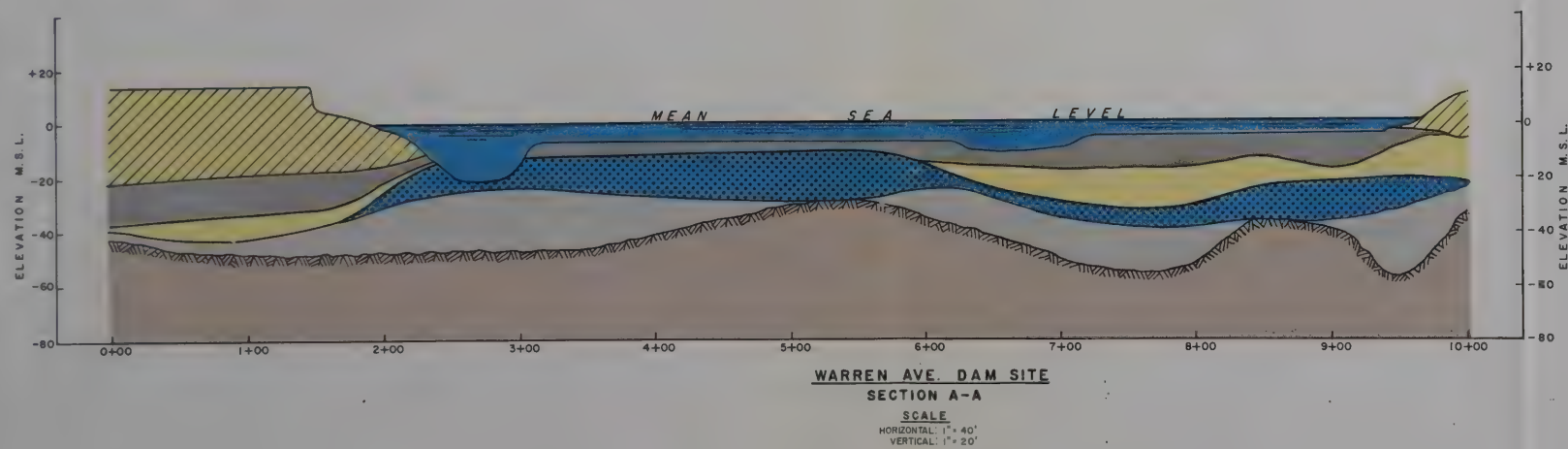
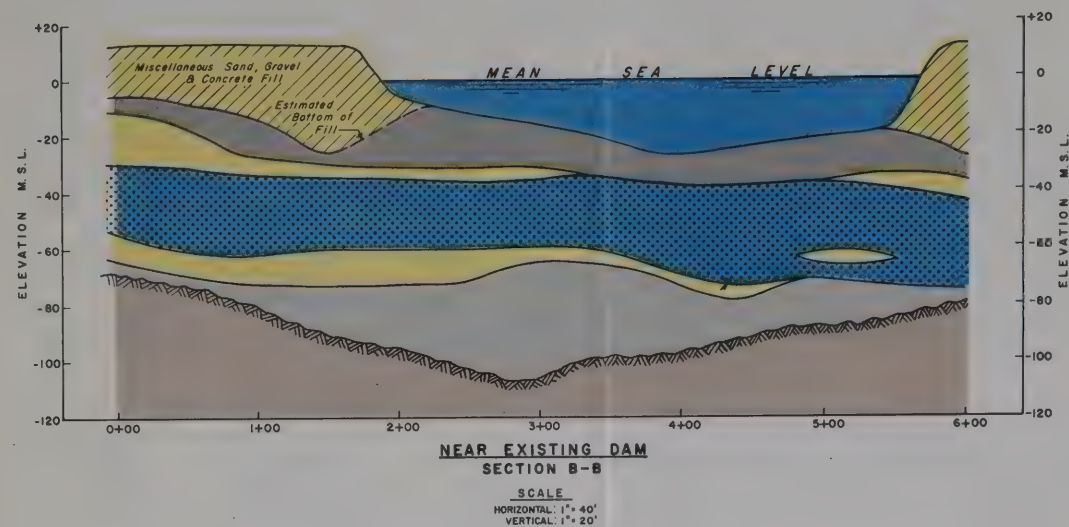
LEGEND

-  FIRM GROUND
-  MUD FLATS
-  TIDE MARSH

CHARLES RIVER INTERIM REPORT
LOWER CHARLES RIVER

BOSTON SHORELINE
1775



**LEGEND**

- FILL
- ORGANIC SILT
- SANDS AND GRAVELS
- SILTS AND CLAYS
- SILTY, CLAYEY GRAVELS AND SAND PARTLY GLACIAL TILL
- BEDROCK SURFACE

DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.		CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER	
SUBMITTED		GENERALIZED GEOLOGIC SECTIONS NEAR EXISTING DAM AND WARREN AVE. DAM SITE	
PROJECT ENGINEER		CHARLES RIVER, MASSACHUSETTS	
REVIEWED		APPROVED DATE MAY 1968	
CHIEF, RIVER BASIN STUDY		CHIEF, ENGINEERING DIVISION	
APPROVAL RECOMMENDED		TO ACCOMPANY REPORT DATED MAY 1968	
CHIEF, PLANNING BRANCH		SCALE AS SHOWN DRAWING NUMBER SHEET	

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

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APPENDIX D HYDROLOGY AND HYDRAULICS

1. INTRODUCTION

This appendix presents climatological and hydrological data for the lower Charles River watershed, a general description of the Charles River Basin and the existing Metropolitan District Commission dam, the analysis of floods of record in the watershed and Basin, development of synthetic floods for the lower watershed and Muddy River, and the study of various plans of improvement.

DESCRIPTION

2. CHARLES RIVER WATERSHED

The Charles River watershed is located in eastern Massachusetts bordering on watersheds of the Mystic, Merrimack, Blackstone, Taunton and Neponset Rivers. The watershed is 307 square miles, including an important and highly developed portion of Metropolitan Boston and less developed but rapidly growing suburban and rural areas.

The watershed is hourglass in shape with a length in a southwest-northeast direction of 31 miles and widths of 15, 6 and 15 miles in a northwest-southeast direction. Elevations vary from 586 feet above mean sea level, along the southwesterly rim of the watershed in Hopkinton, to below 10 feet msl along the lower $8\frac{1}{2}$ miles of the Charles River.

Within the drainage area there are 33 lakes and ponds having a total surface area of 2,532 acres, not including ponded areas along the river itself. The combination of moderate slopes, sandy pervious soil, extensive swamplands, dams and lake storage, all contribute to make the upstream section of the river unusually slow in responding to heavy rains.

3. CHARLES RIVER

The Charles River rises in the town of Hopkinton, approximately 25 miles southwest of the city of Boston. The river follows a general northeasterly course, meandering through extensive swamplands and passing through many heavily built-up areas until it reaches the Charles River Basin, a term commonly used for that portion of the river extending from Watertown to tidewater at the existing Charles River dam. Along its

course the river flows by the towns of Milford, West Medfield, Medfield, South Natick, Charles River Village and Dedham, and the cities of Waltham, Watertown, Newton, Boston and Cambridge.

The river is 80 miles long with a fall from its source to the Charles River Basin of approximately 350 feet. In the lower 33 miles, the drop is 98 feet. There are approximately 22 dams located on the river, some of which are still used for impounding mill process water. A more complete description of the upper Charles River will be included in the comprehensive report.

4. LOWER CHARLES RIVER WATERSHED

a. General. The lower Charles River watershed is assumed, for hydrologic purposes, to extend from the Moody Street dam in Waltham for approximately 12 miles to its mouth at tidewater below the Charles River dam. This assumed subdivision of the total watershed covers an area of 58 square miles. Except for Muddy River, Stony Brook and Beaver Brook, only minor tributaries enter the main stream. Together these three tributaries drain approximately 60 percent of the total drainage area of the lower Charles River. Below Watertown the drainage area comprises a highly concentrated city and suburban-type development with very extensive pavement and roof areas. A comprehensive storm sewer system and tributary inflows discharge into the Basin. These conditions result in high rates of runoff.

b. Beaver Brook. Beaver Brook rises in the town of Lexington and flows in a general southerly direction for 6 miles to its confluence with the Charles River in Waltham. Along the last mile of its length it is inclosed in a conduit. Beaver Brook has a fall of 190 feet and together with its two principal tributaries, Clematis and Chester Brooks, has a total drainage area of 11.2 square miles.

c. Muddy River and Back Bay Fens. Muddy River rises in Jamaica Pond, in the west-central part of Boston, at an elevation of approximately 60 feet msl and flows northerly about 2 miles through a series of small ponds, conduits and channels discharging into the Back Bay Fens through a conduit under Park Drive. This was the mouth of the Muddy River in former times, and the Back Bay Fens was a tidal estuary. At this location the drainage area is 6.1 square miles. Muddy River drops 56 feet in the first 2,000 feet below Jamaica Pond. The remaining length of the river is very sluggish and during normal flows remains at a nearly constant level of 3.0 feet msl. The dry weather flow of Muddy River continues northerly about 2,000 feet in a conduit under Brookline Avenue and Deerfield Street and empties into the Charles River Basin about 3 miles above the Charles River dam.

The Muddy River in Back Bay Fens flows through a series of conduits and open channels with landscaped banks for a distance of about 1.2 miles. The flow continues for nearly 0.4 mile mainly through conduits

and under numerous bridges to the Charles River Basin at a point upstream of the Massachusetts Avenue bridge. The Fens, in the backwater of the Charles River Basin, has a local drainage area of 1.1 square miles. About 1 mile above the Fens outlet at the Basin, two gate-houses control the discharge of storm overflow from Stony Brook into the Fens. Stony Brook rises in Turtle Pond in Stony Brook Reservation and flows in a general northerly direction for a distance of approximately 7 miles. This stream follows the old course of Stony Brook and has a total drainage area of 13.9 square miles. Except for 1 mile at its upper end, the brook is now inclosed in a conduit. All of the dry weather flow and part of the storm flow are carried in the Stony Brook conduit and discharged into the Boston Marginal conduit. This conduit follows the south bank of the Basin and empties into the tidal portion of the Charles River just downstream of Charles River dam.

d. Elevations. Due to local familiarity with MDC datum, elevations pertaining to the Charles River basin are presented in both feet above mean sea level (MSL) and feet above the MDC datum (MDC). The MDC datum is 105.6 feet below 0.0 MSL.

e. Charles River Basin. The Charles River Basin refers to that portion of the river extending from the Metropolitan District Commission dam at Boston to the Watertown dam. Most of this reach was a tidal estuary until construction of the MDC dam in 1910.

Completion of this project afforded protection from extreme high tides to areas located upstream and made it possible to maintain a constant basin level, thereby eliminating unsightly mud flats at low tide. Intercepting sewers were also constructed along both banks of the Charles River to reduce pollution in the Basin. Construction of the MDC dam has made a vast improvement in upstream conditions along the river. Some of the problems encountered in the Basin in recent years will be discussed later in this appendix.

The Charles River dam is a low earth fill structure connecting Boston and Cambridge along Leverett Street, one of the most heavily traveled roads in the metropolis. The dam, with top elevation 15.4 msl (121.0 MDC), is 1,200 feet long and from 100 to 500 feet in width with vertical walls of cut granite blocks. A main feature of the dam is the navigation lock which is 45 feet wide with a clear distance of 350 feet between lock gates. Elevation of the upper gate sill is -18.7 feet msl. The lock gates are horizontal beam-type which operate on a track. The lock gates cannot be operated with any appreciable head against them and therefore are opened or closed only when the water level is the same on both sides of the gate. The hydraulic facilities also include a sluiceway and 8 sluice gates, each 7 x 10.5 feet which are used to control the Basin level.

The normal Basin elevation of 2.4 feet msl is equivalent to 108.0 feet MDC datum. This elevation, selected to give the maximum benefit to

upstream areas, is lower than the mean high tide, therefore, for a period of 4 or more hours during each tide cycle, the sluice gates are closed to prevent salt water inflow from the harbor. With normal run-off or moderate floods there is sufficient storage in the Basin so that closure of sluice gates during this period results in only a minor rise in the Basin level.

Upstream of the dam the Basin has a maximum width of about 2,000 feet, which gradually decreases to less than 400 feet at the Boston University campus about 3 miles upstream of the dam. Above this location the Basin resembles a river with banks generally from 300 to 500 feet apart. At the Watertown dam, about $8\frac{1}{2}$ miles upstream of the Charles River dam, the width is further reduced to 150 feet. The Basin depth generally varies from 15 feet near the origin to 3 feet in Watertown with maximum depths of approximately 30 feet.

The original Basin produced a water surface area of 776 acres at normal pool level. Since 1908 the Basin has decreased 101 acres with the construction of Storrow Drive and recreational areas, and at present the water surface area is 675 acres. The effect of this loss of area on Basin elevations during floods is discussed later in this appendix.

The shoreline involves a length of approximately 20 miles with adjoining areas generally low, particularly in Back Bay and parts of Cambridge. There are extensive areas not more than 7 feet above the normal Basin level and a few areas only 5 feet above normal.

CLIMATOLOGY

5. GENERAL

The lower Charles River watershed has a variable climate characterized by frequent but usually short periods of precipitation. The lower watershed lies in the path of "prevailing westerlies" and cyclonic disturbances that cross the country from the west or southwest. It is also exposed to occasional coastal storms, some of tropical origin, that travel up the Atlantic seaboard. In late summer and autumn months these storms occasionally attain hurricane intensity. Precipitation, temperature and snowfall data at Boston, Chestnut Hill and Blue Hills, Massachusetts are tabulated in tables D-1 through D-4.

6. TEMPERATURE

The average annual temperature of the lower Charles River watershed is about 50° Fahrenheit. The yearly range of mean monthly temperature is wide, with temperatures ranging from 67 to 72 degrees Fahrenheit in July and August, and from 25 to 29 degrees Fahrenheit in January and February. Temperature extremes range from occasional highs slightly in excess of 100° F. to infrequent lows below minus 20° Fahrenheit.

TABLE D-1

MONTHLY TEMPERATURES AND PRECIPITATION
BOSTON, MASSACHUSETTS

<u>Month</u>	<u>Temperature</u> <u>96 Years of Record</u>			<u>Precipitation</u> <u>96 Years of Record</u>		
	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	29.1	72	-13	3.65	9.54	.92
February	29.2	68	-18	3.34	7.04	.45
March	37.6	86	- 8	3.81	11.00	T
April	47.2	91	11	3.58	9.14	.93
May	57.9	97	31	3.21	13.38	.25
June	67.3	100	41	3.13	9.13	.27
July	72.3	104	50	3.22	11.69	.52
August	71.4	101	46	3.62	17.09	.39
September	64.3	102	34	3.21	10.94	.21
October	55.0	90	25	3.28	8.84	.06
November	44.5	83	- 2	3.79	11.03	.59
December	32.8	69	-17	3.45	8.49	.66
ANNUAL	50.7	104	-18	41.29	17.09	T

TABLE D-2

MONTHLY TEMPERATURE AND PRECIPITATION
CHESTNUT HILL, MASSACHUSETTS

<u>Month</u>	<u>Temperature</u> <u>81 Years of Record</u>			<u>Precipitation</u> <u>94 Years of Record</u>		
	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	28.2	70	-17	4.02	9.95	1.64
February	28.2	68	-19	3.78	8.74	0.77
March	36.5	85	- 3	3.98	8.78	T
April	47.5	90	9	3.80	9.19	0.75
May	58.4	96	26	3.35	13.12	0.43
June	67.1	100	35	3.34	9.80	0.20
July	72.5	106	41	3.45	9.73	0.35
August	69.5	100	40	3.76	17.57	0.28
September	63.8	100	30	3.61	11.56	0.35
October	53.5	91	19	3.52	9.62	0.12
November	42.7	83	6	4.01	8.29	0.92
December	31.4	68	-14	3.65	8.31	0.72
ANNUAL	49.9	106	-19	44.27	63.10	29.44

TABLE D-3

MONTHLY TEMPERATURE AND PRECIPITATION
BLUE HILLS, MASSACHUSETTS

<u>Month</u>	<u>Temperature</u> <u>132 Years of Record</u>			<u>Precipitation</u> <u>81 Years of Record</u>		
	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
January	25.1	68	-16	4.20	10.97	.89
February	25.5	67	-21	3.86	8.29	1.04
March	33.4	85	- 5	4.20	9.53	.06
April	43.8	89	6	3.85	8.71	.92
May	54.9	93	27	3.50	9.16	.50
June	63.8	99	36	3.40	10.78	.53
July	69.3	99	46	3.65	11.67	.13
August	67.4	101	39	4.03	18.78	1.22
September	60.7	99	28	3.99	11.04	.45
October	50.5	88	21	3.82	10.84	.22
November	39.5	81	5	4.14	9.29	.63
December	28.5	68	-19	4.00	9.01	.92
ANNUAL	46.9	101	-21	46.64	18.78	.06

TABLE D-4

MEAN MONTHLY SNOWFALL
(Depth in Inches)

<u>Boston, Massachusetts</u> <u>Elevation 15 Feet msl</u> <u>32 Years of Record</u>		<u>Blue Hills, Massachusetts</u> <u>Elevation 640 Feet msl</u> <u>75 Years of Record</u>	
<u>Month</u>	<u>Snowfall</u>	<u>Month</u>	<u>Snowfall</u>
January	12.7	January	15.9
February	11.4	February	16.5
March	8.3	March	11.4
April	0.8	April	3.1
May	T	May	0.1
June	T	June	0
July	T	July	T
August	T	August	0
September	0	September	T
October	T	October	0.2
November	1.3	November	2.7
December	7.2	December	10.5
ANNUAL	41.7	ANNUAL	60.4

7. PRECIPITATION

The average annual precipitation of the lower Charles River watershed is about 43 inches distributed rather uniformly throughout the year. At any one station the range between maximum and minimum values of average monthly rainfall is only about 1 inch.

8. SNOWFALL

The annual snowfall over the watershed varies from approximately 42 inches at Boston on the coast to 60 inches at the Blue Hills Observatory, 640 feet above mean sea level. Snow cover reaches a maximum depth in early March with the water content in early spring often exceeding 2 inches.

9. STORMS

The rapidly moving cyclonic storms or "lows" that move into New England from the west or southwest produce frequent periods of unsettled but not extremely severe weather. The region is also exposed to occasional coastal storms, some of tropical origin, that travel up the Atlantic coast and move over or within striking distance of the New England states.

The most severe storms have been of tropical origin which occur during late summer and early autumn. The five notable recent storms in the Charles River watershed occurred in March 1936, July 1938, September 1954, August 1955 and March 1968. The hurricane "Diane" storm of August 1955 produced floods throughout much of southern New England. The accompanying rains fell on ground previously saturated by rainfall from hurricane "Connie" which occurred one week earlier. Rainfall amounts, for the period from the 17th - 20th, ranged from about 10 to 13 inches over the lower watershed.

10. STREAMFLOW DATA

The U. S. Geological Survey has maintained and published records of 4 stream gaging stations in the Charles River watershed. Streamflow records at the gaging stations are summarized in table D-5. Mother Brook at Dedham, Massachusetts is a diversion from the Charles River to the Neponset River. The gage is located 0.4 mile downstream from the point of diversion from the Charles River.

11. TIDE DATA

The normal tide range in Boston Harbor between mean low water (elevation 4.9 feet below msl), and mean high water (elevation 4.6 feet above msl) is 9.5 feet. Mean high and maximum high spring tide levels are about 4.6 and 6.5 feet msl, respectively. The high tide during the record storm of August 1955 rose to elevation 6.9 feet msl (112.5 feet MDC

TABLE D-5
STREAMFLOW RECORDS

<u>Location of Gaging Station</u>	<u>Drainage Area (sq.mi.)</u>	<u>Period of Record</u>	<u>Discharge (cfs)</u>		
			<u>Mean*</u>	<u>Maximum</u>	<u>Minimum Daily</u>
Charles River at Charles River Village	184	1937-1968	292***	3,220	0.9
Mother Brook at Dedham	-	1931-1968	77	1,040	0
Charles River at Wellesley	211	1959-1968	302***	2,400	1.0
Charles River at Waltham	227**	1931-1968	368***	2,620	0.2

* Does not include data for period 1966 - 1968

** Excludes 23.6 square miles drained by Stony Brook

*** Adjusted for diversions at Mother Brook and
municipal water supplies

datum). The maximum tide of record in the harbor is 10.1 feet msl (115.7 feet MDC). There is evidence that sea level is slowly rising, with the present rate believed to be about 0.6 foot per century. However, this has no appreciable effect on the hydraulics of the Basin. Table D-6 shows a tabulation of storm tide levels at Boston, Massachusetts.

TABLE D-6

STORM TIDE LEVELS AT
BOSTON, MASSACHUSETTS
(Harbor Side of Dam)

<u>Date</u>	<u>Elevation</u> <u>(ft,msl)</u>
16 April 1851	10.0*
26 December 1909	10.0
27 November 1898	9.5
29 December 1959	9.4
21 April 1940	9.0
4 March 1931	8.8
30 November 1944	8.8
20 January 1961	8.8
7 March 1956	8.6
7 April 1958	8.5

* Measured at U. S. Navy Yard

FLOODS OF RECORD

12. GENERAL

Outstanding floods on the Charles River may be expected to occur during any season of the year. Early spring rains combined with melting snow resulted in the floods of March 1936 and March 1968. Heavy rains during summer months caused the floods of July 1938 and August 1955.

13. HISTORIC FLOODS

Records of floods in the Charles River watershed prior to the turn of the century are meager. From all available information the greatest flood prior to 1900 occurred in February 1886. Other noteworthy floods of the period occurred in 1807 and 1818.

14. RECENT FLOODS

Five floods of major proportions have occurred on the Charles River in recent years: March 1936, July 1938, September 1954, August 1955 and March 1968. A brief description of each is given in the following paragraphs:

a. March 1936 flood. This flood, marked by two distinct peaks spaced about 6 days apart, resulted from a combination of runoff from melting snow and heavy rainfall from two major storms over the watershed. Rainfall amounts for the combined storms ranged from 4.5 inches in the lower watershed to more than 7 inches in the upper areas. On the Charles River at Charles River Village a peak discharge of 3,170 cfs was recorded at the USGS gaging station. The March 1936 flood produced a maximum Basin elevation of 3.7 feet msl (109.3 MDC) or 1.3 feet above normal.

b. July 1938 flood. During a 7-day period from 18 to 24 July torrential rains fell throughout the Charles River watershed resulting in near record flood levels along the main stem. A total of 9.2 inches of rainfall was measured at Brookline, Massachusetts. In the upper portion of the watershed at Milford, 12.3 inches of rain was recorded. Rainfall amounts in the lower watershed ranged from 4.0 inches at Boston to 7.7 inches at Framingham. The July 1938 flood resulted in the basin level rising to approximately 1 foot above normal.

c. September 1954 flood. The storm which accompanied hurricane "Carol" on 11-12 September 1954 produced the third highest stage in the Charles River Basin. An elevation of 4.93 feet msl (110.55 MDC) was recorded at the Charles River dam. A total storm rainfall of 6.32 inches was measured by the U. S. Weather Bureau at Boston. The maximum tide associated with hurricane "Carol" was 6.4 feet msl (112.0 MDC).

d. August 1955 flood. This flood, one of the greatest of record on the Charles River, resulted from record rainfall accompanying hurricane "Diane" falling on ground previously saturated by the precipitation of hurricane "Connie" which occurred only a week earlier. Hurricane "Connie", 11-15 August, caused rainfall varying from 4 to 6 inches over southern New England and ended a period of drought. A week later, on 17-20 August, hurricane "Diane" brought rainfall from 16 to 20 inches over Massachusetts. Rainfall totals for hurricane "Diane" at Boston and Chestnut Hill were 12.5 and 13 inches, respectively. This storm produced abnormally high tides in Boston Harbor. This condition combined with high local runoff resulting from very intense rainfall produced a record Basin elevation of 6.9 feet msl (112.5 MDC), 4.5 feet above the normal level.

e. March 1968 flood. Heavy rainfall occurring over southern New England on 17-18 March resulted in the second largest flood of record in the lower reaches of the Charles River. Highest amounts of precipitation fell in the area just southwest of Boston with 7.7 inches measured

at Blue Hills. The Charles River Basin rose 2.85 feet above normal and inundated sections of Storow Drive. This is the second highest rise in the Basin exceeded only by the 4.5 foot rise in August 1955.

15. FLOOD PROFILES

High water profiles on the Charles River were determined from field surveys after the floods of March 1936 and August 1955. Water surface profiles of the lower Charles River watershed for these floods are shown on plate D-1.

16. FLOOD PROBLEM IN CHARLES RIVER BASIN

The flood problem in the Charles River Basin and surrounding low areas in Cambridge and the Back Bay section of Boston is caused basically by the difference in the established normal water level in the Basin and high tide in the harbor. The Basin level is 2.5 feet below mean high water in the harbor which necessitates storing the flow into the Basin for a period of 4 to 6 hours during every high tide cycle. This can be accomplished without difficulty during normal flows and even minor floods. Major storms and high rates of inflow during the high tide cycle, inadequate discharge capacity of the sluice gates during low tides, urban expansion, and encroachments affecting the storage capacity of the Basin have all combined to produce progressively higher uncontrollable Basin elevations. There are many hydrologic and hydraulic aspects of the problem which will be described in the following paragraphs.

ANALYSIS OF FLOODS

17. GENERAL

In John R. Freeman's Report of the Committee on the Charles River published in 1903, consideration was given to flood inflows from the entire watershed of 307 square miles. Based on flow records at Waltham, it was concluded that the Charles River reacted very slowly to intense storms and that it took several days before runoff from the upper watershed would reach the Basin. The original design flood for the Basin had a peak inflow of 7,000 cfs. The early engineers, not anticipating the rapid urban growth of greater Boston, considered that the design flood for the Basin would develop from the upstream watershed of the Charles River. The maximum stage in the Basin from the design flood was estimated to be well below the high water stages previously experienced from abnormally high tides.

18. ANALYSIS OF FLOODS

The major floods of record in the Basin were analyzed to determine

the hydrologic development of the floods and tributary components contributing to the crests. Pertinent features of the August 1955, October 1962 and March 1968 floods are shown on plates D-2 and D-3.

Basic data for this analysis include Basin elevations at the MDC Charles River dam, discharge records at the USGS gaging station at Waltham, and rainfall records maintained by the U. S. Weather Bureau at Cambridge and Logan Airport in East Boston. These records are continuous throughout the several flood periods studied.

Records of concurrent harbor and Basin levels have been maintained at the MDC dam since its completion in 1910. These records also include operational data for the sluice and lock gates. There are 8 gravity sluice gates used to control the Basin level, each 7 x 10.5 feet and normally either closed or fully opened. Discharge through these gates depends on the differential head between the Basin and harbor. With the Basin at its normal elevation of 2.4 feet msl (108.0 MDC) each gate can discharge about 700 cfs with the harbor at msl or lower.

The Basin is predrawn by the MDC in anticipation of a serious storm. Elevation 0.9 feet msl (106.5 MDC) is the lowest drawdown permitted, and 1.4 feet msl (107.0 MDC) is the usual target. The Basin was drawn down to elevation 1.4 feet msl (107.0 MDC) at the start of the August 1955 storm, then rose during the next high tide cycle to crest elevation at 6.9 feet msl (112.5 MDC).

Inflow to the Basin is the summation of three items: (a) flow at Waltham, (b) rainfall directly on the water surface of the Charles River Basin, and (c) local inflow from adjacent drainage areas. In the analysis of the August 1955 flood, values for the Waltham flow, item (a), were taken from records of the USGS gaging station at Waltham. Rainfall amounts recorded by the U. S. Weather Bureau at Cambridge were applied to the Charles River water surface area for item (b).

Total local inflow was computed by the conventional routing computation relating the change in Basin storage, as determined from the elevation levels, with the outflow through the sluice and lock gates. Local inflow to the Basin was determined by deducting items (a) and (b) from the total inflow.

The high peak inflows are now experienced within an hour following an intense storm indicating the importance of local drainage to the Basin. Hydrologically, it is now considered that the rapid flood runoff from the lower 56 square miles of Charles River watershed between Moody Street dam and the existing Charles River dam is the principal cause of the flood problems during recent record floods.

The relative contributions from the lower and upper watersheds to the peak rate of inflow, and the volume of inflow producing the highest elevation in the Basin are shown in table D-7.

TABLE D-7

EFFECT OF UPPER AND LOWER WATERSHEDS
ON BASIN ELEVATIONS DURING FLOODS

Item	Floods					
	1954	1955		1962		SPF
	CFS	%	CFS	%	CFS	%
Peak Inflow	9,600		15,000		4,800	
Upper Watershed*	900	9	1,300	9	1,800	38
Lower Watershed**	8,700	91	13,700	91	3,000	62
	Acre- Feet	%	Acre- Feet	%	Acre- Feet	%
Volume of Inflow						
Producing Highest Elevation in Basin	3,450		6,200		1,900	
Upper Watershed*	350	10	1,120	18	825	44
Lower Watershed**	3,100	90	5,080	82	1,075	56
Maximum Basin Elevation						
MSL	4.9		6.9		5.2	
MDC	110.5+		112.5		110.8+	

* Upstream of USGS gaging station in Waltham, Drainage Area = 251 square miles

** Downstream of USGS gaging station in Waltham, Drainage Area = 56 square miles

The combination of increased urban development and loss of Basin storage capacity has resulted in a progressive rise in flood stages in the Basin since its completion. The phenomenal storm produced by the "Diane" hurricane in August 1955 resulted in a stage surpassing all previous records. It is estimated that the decrease in Basin area between 1908 and 1955 raised the "Diane" flood stage about one-half foot above what would have occurred with the original Basin area.

19. FLOOD FREQUENCIES

Since completion of the MDC dam in 1910, there have been numerous floods in which the Basin level rose above its normal elevation of 2.4 feet msl (108.0 MDC). Selected high stages in chronological order are as follows:

<u>Year</u>	<u>Basin Elevation</u>	
	<u>Feet MSL</u>	<u>Feet MDC</u>
1911	3.48	109.10
1924	3.95	109.57
1931	4.20	109.82
1932	4.26	109.88
1938	4.15	109.77
1947	4.68	110.30
1949	4.44	110.06
1954	4.93	110.55
1955	6.88	112.50
1962	4.02	109.64
1968	5.23	110.85

Plate D-4 shows the maximum Basin elevations attained by all independent rises which equalled or exceeded 3.4 feet msl (109.0 MDC) in the period from 1911 to 1968. This plate shows the progressive rise in Basin levels which is considered to be the overall result of expanding urban development and decrease in storage capacity of the Basin. From this progressive rise and its accompanying frequency lines, it appears that the Basin level of 3.48 feet msl (109.10 MDC) experienced in July 1911 would be about 4.01 feet msl (109.63 MDC) under present conditions.

In developing a frequency curve for the Basin, the experienced rises were adjusted to 1968 conditions by following the estimated frequency lines shown on plate D-4. The resulting stages were then arranged in decreasing order. The percent chance of occurrence in any one year was computed by the formula: $P = \frac{100 (M-0.5)}{Y}$

where P = percent chance
 M = number of the event
 Y = number of years of record

The elevation of the August 1955 flood is estimated to have a 1 percent chance of occurrence. Plate D-5 shows the elevation-frequency curves for the Charles River Basin under existing conditions with several pumping capacities. The projected elevation-frequency curve for the year 2020, assuming urban development continues at the same rate as in the past, is also shown on plate D-5.

STANDARD PROJECT FLOOD

20. GENERAL

A standard project flood (SPF) was developed for the lower Charles River watershed to use as a basis for design of proposed improvements. The SPF was based on a standard project storm centered over the 58 square miles of watershed downstream of Waltham. An estimated coincident flow from the upper watershed was added to the downstream flood hydrograph.

The adopted standard project flood for the lower Charles River watershed was derived principally on a volume basis. With the limited discharge capacity of the existing MDC dam and two periods each day when the harbor is higher than the Basin level, volume of inflow rather than peak flow becomes the most critical factor.

21. STANDARD PROJECT STORM

The standard project storm (SPS) for the lower Charles River watershed was based on criteria prescribed in Civil Engineering Bulletin 52-8. Comparison of the SPS with the August 1955 storm is shown in the tabulation below:

<u>Time</u>	<u>19 August 1955</u>	<u>SPF</u>
0	0	0
3	0.18	0.25
6	2.18	2.94
9	4.33	5.96
12	0.62	0.82
15	0.56	0.56
18	0.24	0.44
TOTALS	8.11	10.97

22. STANDARD PROJECT FLOOD

The local runoff for the August 1955 flood, as shown on plate D-2,

was used as a guide for the SPF. The net local runoff from the 19 August precipitation, deducting the recession runoff from the 18 August rains, amounted to 5.48 inches indicating a loss of 2.64 inches in the 18-hour period. Assuming the same loss applicable to the SPF for the same 18-hour duration results in rainfall excess of 8.33 inches. Hence, ratio of the rainfall excess of the SPF to the 19 August storm is 8.33 divided by 5.48, which is 1.52. The hourly values of the SPF local inflow were determined by multiplying the hourly local inflows for the 1955 flood by 1.5, after adjusting for the estimated recession from the previous day's runoff.

The Charles River flow at Waltham was assumed to reach a peak discharge of 3,000 cfs in 12 hours and to remain constant at that value for the duration of the flood. The summation of local inflow, SPS rainfall on the water surface of the Basin and Waltham inflow, produced a standard project flood peak of 21,000 cfs. This is 40 percent higher than the estimated 15,000 cfs for the record flood of August 1955. Coincident with the SPF, it is assumed that tides in Boston Harbor were similar to those experienced during the critical tide cycle on 19 August 1955 when the high tide rose to elevation 6.9 feet msl (112.5 MDC), or 2 feet above mean high tide.

Flood hydrographs of the standard project and August 1955 floods are shown on plate D-2. The hydrograph for the March 1968 flood is shown on plate D-3.

PLAN OF IMPROVEMENT

23. CHARLES RIVER DAM

The plan consists of a new dam with pumping and locking facilities which would be located 2,250 feet downstream of the existing dam. The new location will add 45 acres of water surface area to the Basin which will be maintained at the same elevation as the existing Basin. The additional water area will compensate for the increase in watershed of about 2 square miles. Pertinent data pertaining to the hydrologic and hydraulic features of the new dam are as follows:

- a. A station would be provided with pumping capacity totaling 8,400 cfs. Six pumps would be installed, each with a design capacity of 1,400 cfs.
- b. Three locks, one large and two small, would be provided to improve navigation facilities. The locks, provided with sector gates, could be used for sluicing water from the Basin to the harbor during large floods.
- c. The lock filling and emptying system will be used for sluicing

riverflows from the Basin to the harbor. When riverflows exceed the capacity of the lock culverts, water will be either sluiced through a lock when conditions permit or pumped when the tide is higher than the Basin level.

d. Tentatively, the minimum top elevation of the dam will be 12.4 msl (117.8 MDC) or about 2 feet higher than the maximum tide of record. Most of the dam crossing the river consists of the pumping station and locks with concrete walls where freeboard is not a serious factor. A viaduct crossing the dam with a vertical curve to provide navigation clearance at the locks will tend to provide adequate freeboard on both sides of the dam. Freeboard requirements will be further checked as details of the dam are developed.

e. Upon completion of the new dam, sluice and lock gates at the existing dam will be permanently placed in an open position.

24. PUMPING REQUIREMENTS

Three basic conditions to be considered in the determination of pumping capacity are: (1) volume of inflow, (2) maximum tide conditions, and (3) period of time high tide remains above Basin level. Various combinations of these conditions were tested, assuming the following basic rules of operation:

a. The Basin drawn down to elevation 1.4 feet msl (107.0 MDC) at the beginning of flood.

b. No pumping until Basin reaches elevation 1.9 feet msl (107.5 MDC) or higher, then assume full pumping capacity.

A stage-frequency curve of Basin elevations under existing conditions and with various pumping capacities is shown on plate D-5.

25. SELECTED PUMPING CAPACITY

A pumping capacity of 8,400 cfs would hold a recurring 1955 flood to a maximum Basin elevation of 3.1 feet msl (108.7 MDC) or only 0.7 foot above normal. With 1 pump inoperative the Basin would be 1.6 feet above normal. Similarly, using the assumed criteria described in paragraph 24, the standard project flood could be maintained at a maximum Basin level of 5.1 feet msl (110.7 MDC) with 6 pumps and 5.7 feet msl assuming 1 pump inoperative.

The capacity of either 5 or 6 pumps would be adequate to hold the Basin below damaging stages for the 1955 flood, the maximum of record. The pumps actually have reserve capacity for floods larger than experienced in 1955, thus providing for further urban development and faster runoff in the lower watershed.

Considering the rarity of the SPF it is considered appropriate to assume that all pumps are operative. The estimated damage at a Basin level of 5.1 feet msl is about \$400,000. A 7th pump, increasing the total capacity to 9,800 cfs, would reduce the maximum basin level during the SPF to 4.4 feet msl with damage of \$100,000. A 7th pump, and a longer pumping station and necessary accessories, would cost in excess of \$1 million. The cost of a 7th pump cannot be justified to save \$300,000 during an infrequent SPF. The benefit-cost ratio for a 7th pump is approximately 0.6.

Considering all aspects of the flood problem, particularly the type of shallow inundation damage caused by high river stages, the fact there is no velocity of flow to destroy buildings, and there is no serious hazard to loss of life, it is concluded that the selected pump capacity of 8,400 cfs provides a high and reasonable degree of protection to the communities surrounding the Charles River Basin.

OTHER IMPROVEMENTS STUDIED

26. MUDDY RIVER FLOOD PROBLEM

a. General. The flooding of lowlands in the area of Back Bay Fens and along Muddy River presents a secondary flood problem in the lower Charles watershed. The problem is caused by overflows to the Fens from Stony Brook conduit, high flows in Muddy River, and backwater from the pool of the Charles River Basin. Lowering the Basin levels during a flood is a prerequisite before other improvements in the Fens and Muddy River can be effective.

b. Factors causing problem. The record high flood stages experienced in August 1955, occurring in the channel storage pool of the Muddy River upstream of Park Drive, were produced by a combination of the following factors:

- (1) High stage in the Charles River Basin.
- (2) Bridge and channel restrictions in the lower Muddy River between Boylston Street and the Basin.
- (3) High rates of discharge probably augmented by overflow from the Stony Brook conduit.
- (4) Flat gradients and insufficient channel capacity in the Fenway.
- (5) Inadequate culverts under the Sears Roebuck parking area.
- (6) Uncertain discharge capacity of Brookline Avenue conduit, but probably small due to silting, debris and effect of inverted siphons.

c. Existing and proposed drainage improvements. There are four principal drainage outlets in Brookline discharging into Muddy River, namely, Village Brook, Tannery Brook, Longwood Avenue and Chestnut Street. Collectively these drains have a discharge capacity of about 1,700 cfs, equivalent to 425 csm (2,550 acres) or a runoff of 0.66 inch per hour. Due to different times of concentration in the various drainage systems, peak flows in the drains may not coincide and hence may not be additive.

Consultants for the town of Brookline have proposed a plan to augment the present drainage system. The improved system, based on 25-year frequency rainfall, would increase the discharge capacity to about 3,300 cfs, assuming that improvements were made in Muddy River to limit the rise in flood stages in the channel storage between Leverett Pond and Park Drive to elevation 115 (MDC Base). This discharge is equivalent to 825 csm, or a runoff of 1.3 inches per hour.

d. Flood analysis. An analysis has been made of three significant floods on the Muddy River. Pertinent features of the August 1955, October 1962 and project design floods are shown on plate D-7 and listed in table D-8.

e. Rainfall frequencies. The following table lists the 1955 and 1962 storm intensities with their estimated probabilities, the 25, 50 and 100-year storms as taken from USWB Technical Paper 40, and the standard project storm from Civil Engineer Bulletin 52-8.

<u>Storm</u>	<u>Time in Hours</u>						
	<u>1</u>	<u>2</u>	<u>3</u>	<u>6</u>	<u>12</u>	<u>24</u>	<u>48</u>
August 1955 (Cambridge)	1.8	3.2	4.3	6.5	7.8	8.8	12.6
October 1962 (Boston)	0.6	1.0	1.2	1.8	3.0	4.3	7.9
25-Year Frequency	2.1	2.7	3.0	3.7	4.6	5.5	-
50-Year Frequency	2.4	3.0	3.4	4.2	5.1	6.0	-
100-Year Frequency	2.7	3.3	3.7	4.7	5.7	6.8	-
Standard Project Storm	3.4	4.7	6.0	8.9	10.3	11.6	13.2
Design	2.7	3.8	4.8	6.5	7.8	-	-

f. Design storm. As previously noted, the proposed improved drainage system in Brookline would be designed for a 25-year frequency storm. As the time of concentration is generally 1 hour or less, design discharge of the drainage system with proposed improvements is related to the 25

TABLE D-8

COMPARISON OF MUDDY RIVER DESIGN
FLOOD AND EXPERIENCED FLOODS

<u>Flood</u>	<u>Rainfall</u> <u>(inches)</u>	<u>Runoff</u> <u>(inches)</u>	<u>Inflow</u> <u>(cfs)</u>	<u>Outflow</u> <u>(cfs)</u>	<u>Maximum</u> <u>Elevation</u> <u>Muddy River</u> <u>(ft,MDC)(1)</u>	<u>Storage</u> <u>(ac/ft)</u>	<u>Maximum</u> <u>Elevation</u> <u>Charles R.</u> <u>(ft,MDC)(1)</u>
August 1955 (Existing Conditions)	(24 Hours) 8.8	4.0	2,000	1,100	117.9	340	112.5
August 1955 (Improved Conditions)	(24 Hours) 8.8	4.5	2,800	2,000	115.0	180	110.0(2)
October 1962	7.0	3.5	1,100	700	117.0	280	109.6
Design	7.8	4.8	3,500	2,800	115.0	180	110.0

(1) To convert from MDC datum to MSL, subtract 105.62'

(2) Recommended pumping capacity will keep maximum level at 108.7

year, 1-hour intensity. Runoff from rainfall in excess of this intensity will produce overland flow and temporary surface storage. To provide a reasonably high degree of protection for the extensively developed urbanized watershed of Muddy River it is considered that improvements for Muddy River channel should be designed for runoff from 100-year rainfall amounts for the 1-hour duration and the experienced 1955 rainfall for the 6 to 12-hour amounts.

g. Design head. It is assumed that a pumping station of sufficient capacity will hold the Charles River Basin to a maximum elevation of 110.0 feet (MDC datum), and that the Muddy River storage pool upstream of Park Drive will not exceed 115 feet. It is considered unlikely that these two elevations are concurrent as the Basin elevation will depend on the relative timing of the ocean tide and maximum inflow to the Basin from all contributing areas downstream from Waltham. For design of facilities in Muddy River and the Fens, it is considered reasonable to assume a 6-foot differential between the Muddy River storage area, upstream of Park Drive, and the Charles River Basin.

Backwater computations have been performed for the Fens in the reach extending from the mouth at Charles River to the Stony Brook overflow near the Museum of Fine Arts, a distance of about 4,500 feet. A series of bridges and ramps span the lower Fens within the Charlesgate complex. These bridges include Storrow Drive, Beacon Street, Commonwealth Avenue, Massachusetts Turnpike Extension, New York Central Railroad and Ipswich Street. A new relocated channel has been constructed between these structures having a bottom width of 24 feet and 1:2 side slopes. In addition to the existing bridges, several elevated ramps supported by concrete piers which are located within the channel, intersect the reach between Ipswich Street and Storrow Drive.

Measurements made at the entrance of the Storrow Drive culvert indicated a depth of over 2 feet of silt and debris above the invert. Elevation of the invert is about 10 feet below the normal level of the Charles River Basin. It is estimated that silting of the channel extends for some distance upstream.

Backwater studies indicate that under existing conditions a significant increase in water levels upstream of Ipswich Street can be expected for minor and moderate flows. With the elevation of the Charles River Basin at 109 MDC, a flow of 2,000 cfs will produce a water surface elevation of 113.9 upstream of Ipswich Street. This is equivalent to a head loss of 4.9 feet.

Additional backwater computations were conducted in the lower Fens assuming improved channel conditions. These improvements include a dredging of the channel, providing a uniform channel slope, and increasing the cross sectional area at the piers. A Manning's "n" value of 0.025 was used for the main channel section and 0.035 for the overbank. Under the improved conditions, a flow of 2,000 cfs produced a

total head loss of 3.4 feet resulting in a reduction of approximately 45 percent. Listed in the table below are the head losses in feet computed in the reach from the mouth of Muddy River to Stony Brook overflow. The computation was based on the assumption that the Charles River basin was at elevation 109 MDC.

MUDDY RIVER HEAD LOSSES
FROM MOUTH TO STONY BROOK OVERFLOW
(Losses in Feet)

<u>Discharge</u> (cfs)	<u>Existing</u> <u>Conditions</u>	<u>Improved</u> <u>Conditions</u>
2,000	4.9	3.4
3,000	8.7	6.0
4,000	-	9.4

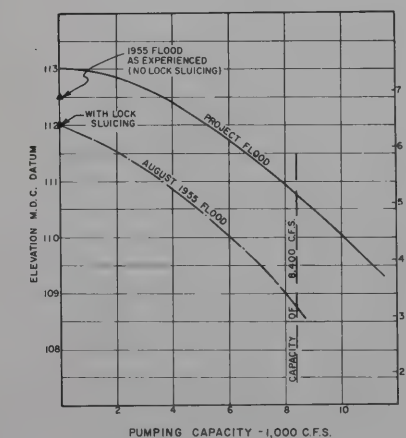
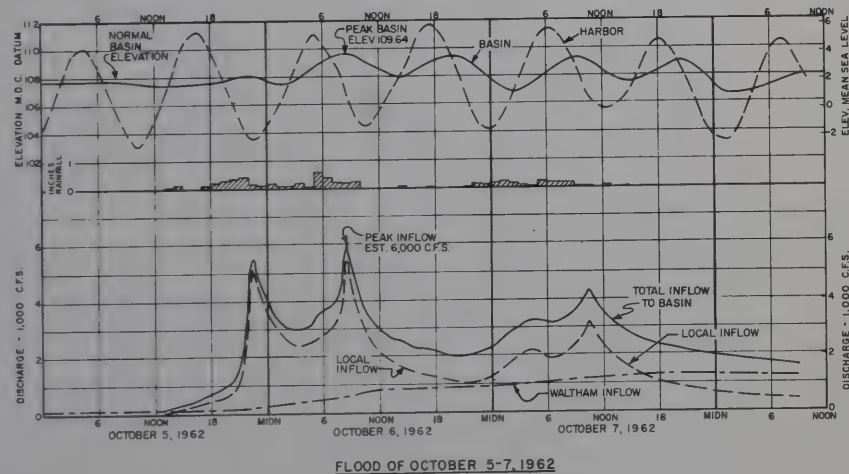
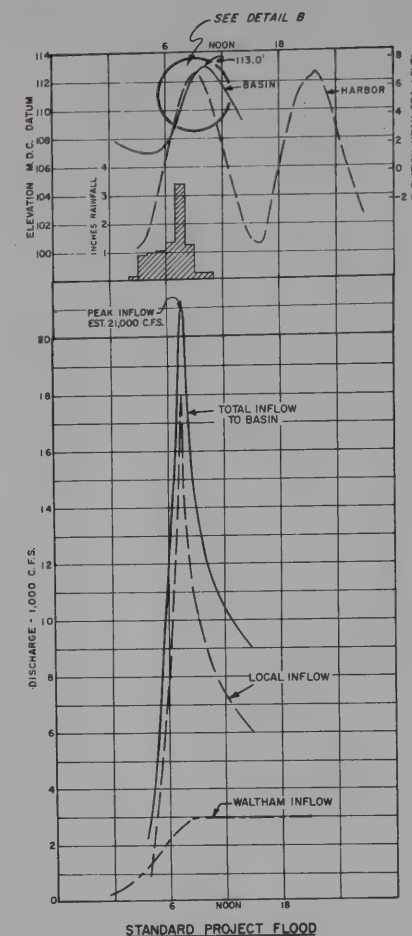
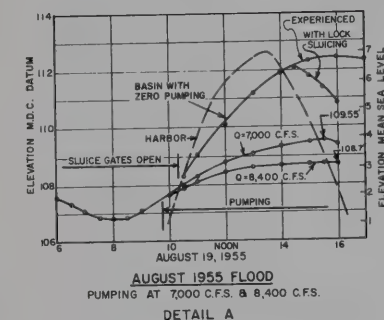
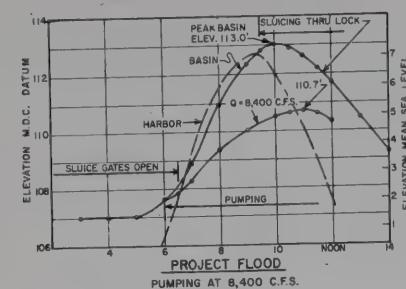
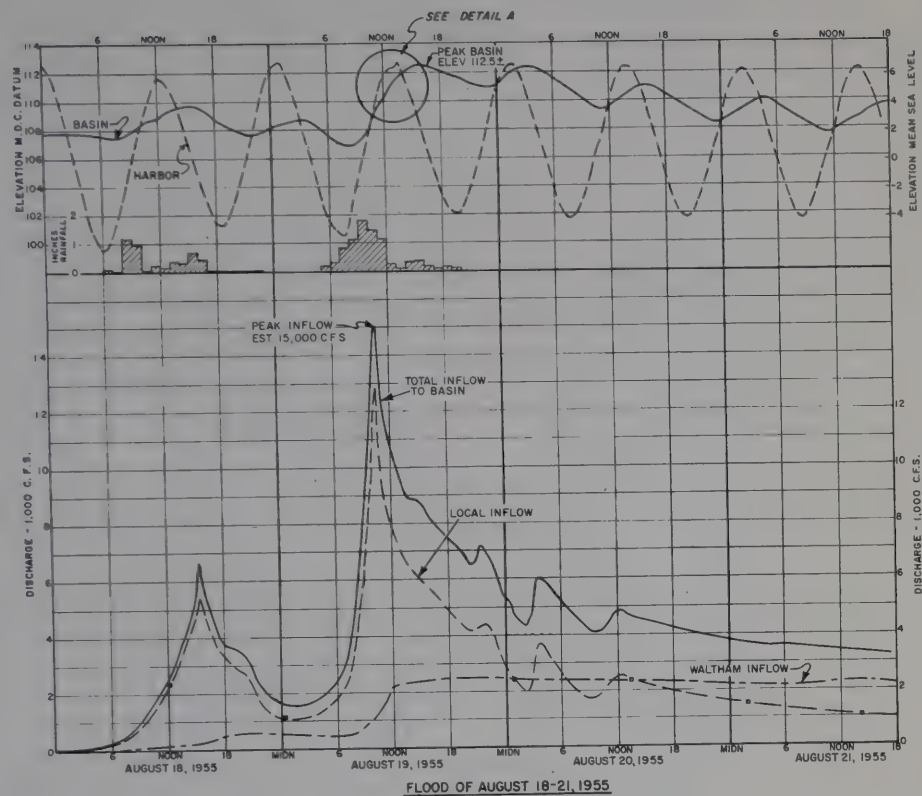
h. Flood frequencies. Elevation-frequency relationships have been estimated for the Muddy River for economic studies. Plate D-5 shows elevation-frequency curves for the Muddy River under existing conditions and with proposed improvements. The curves shown are for two locations: (1) above Park Drive, applicable to the reach from Leverett Pond to Park Drive, and (2) at Agassiz bridge, applicable to the reach from Boylston Street to Park Drive.

1. Inner Belt Expressway. A new facility, the Inner Belt Expressway, Route I-695, may traverse approximately 3,000 linear feet of the Fens at and below the Muddy River conduit at Park Drive. This new expressway, if and when constructed, would cross 2 Stony Brook conduits and the Muddy River conduit at Park Drive and would require a major culvert for the Muddy River at the location where it enters the Fens.

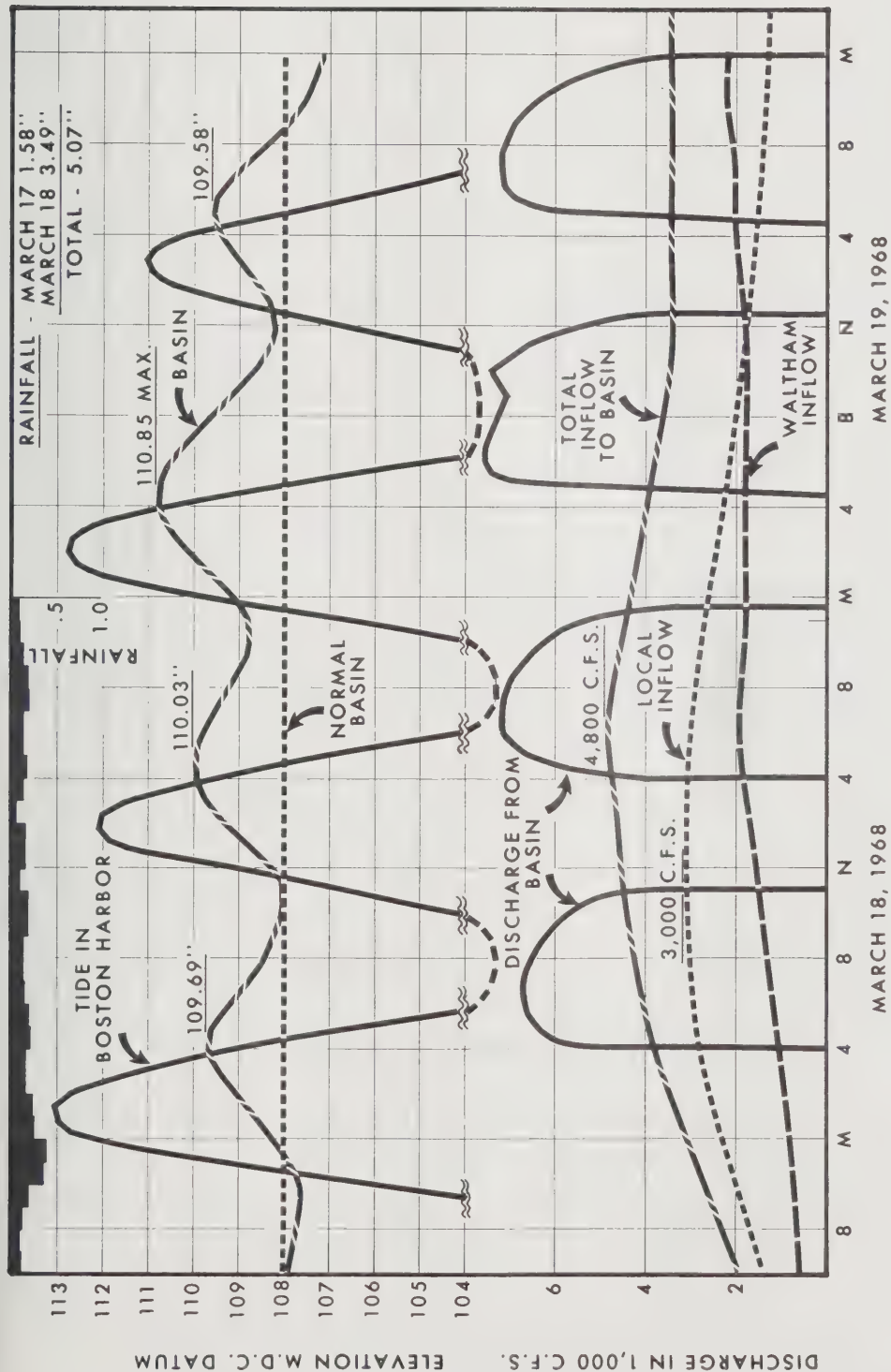
Design of the new expressway provides for 2 Stony Brook siphons under the highway to maintain present flow conditions. No provisions have been advanced as yet for handling floodflows from Muddy River. One method would be to construct a siphon under the future Inner Belt to assure continuance of flows from Muddy River to the Charles River Basin by way of the existing Brookline Avenue and Deerfield Street conduit. Excess flows would pass through the Fens to the Basin. Existing waterway openings in the Fens area are presently inadequate to accommodate the combined floodflow contributions from Stony Brook and Muddy River. Significant enlargement of these openings is necessary if overbank flooding is to be prevented. Improvements of this nature would require extensive and costly construction.

An alternate solution would be to divert floodflows in Muddy River directly to the Charles River Basin by means of a new conduit constructed as part of the new Inner Belt. The Bureau of Public Roads has proposed that this alternative be explored by the Massachusetts Department of Public Works. Should such a conduit be built as part of the Inner Belt, floodflows reaching the Fens would be limited to the Stony Brook contributions and minor alterations in waterway openings would be required to pass future floodflows.





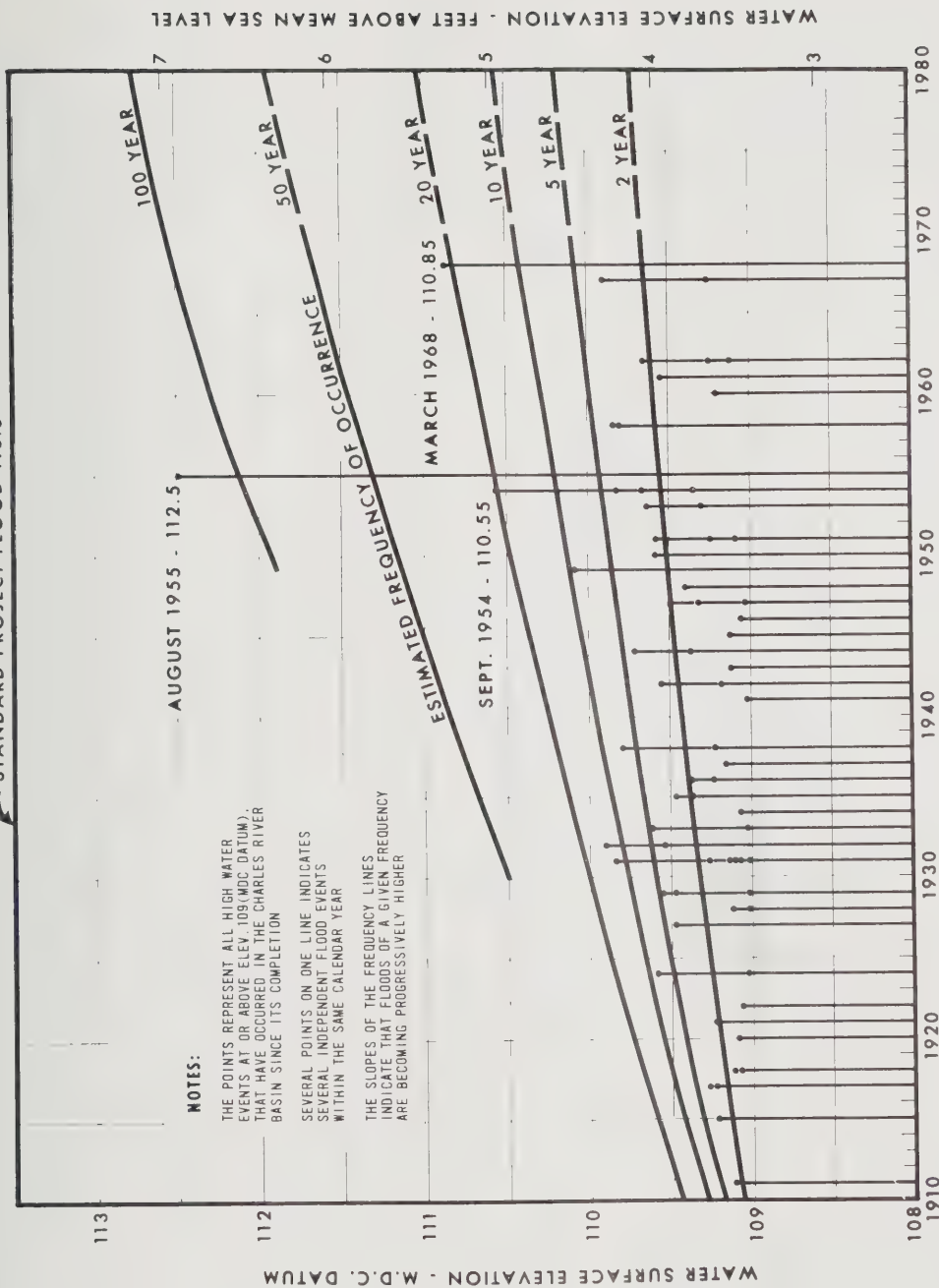
DES. BY			DR. BY			CK. BY		
SUBMITTED								
PROJECT ENGINEER								
REVIEWED								
CHIEF, RIVER BASIN STUDY			CHARLES RIVER,			MASSACHUSETTS		
APPROVAL RECOMMENDED			APPROVED			DATE MAY 1968		
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TO ACCOMPANY REPORT			DRAWING NUMBER			SHEET		
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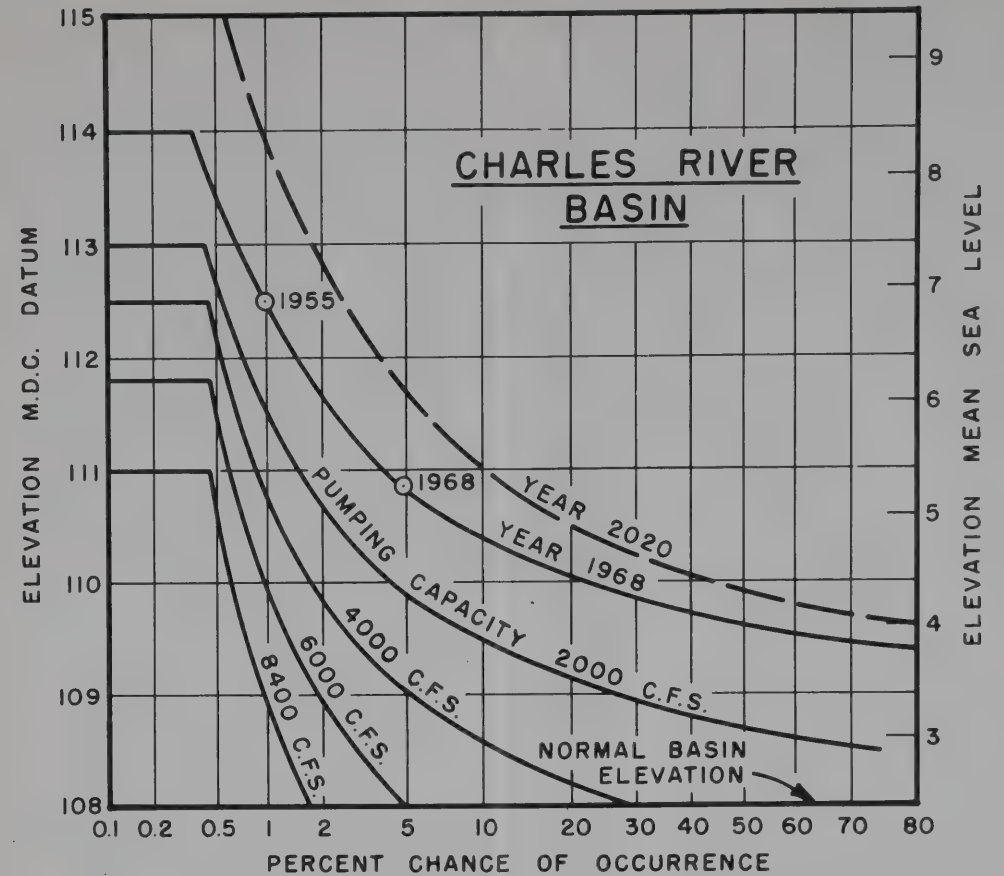
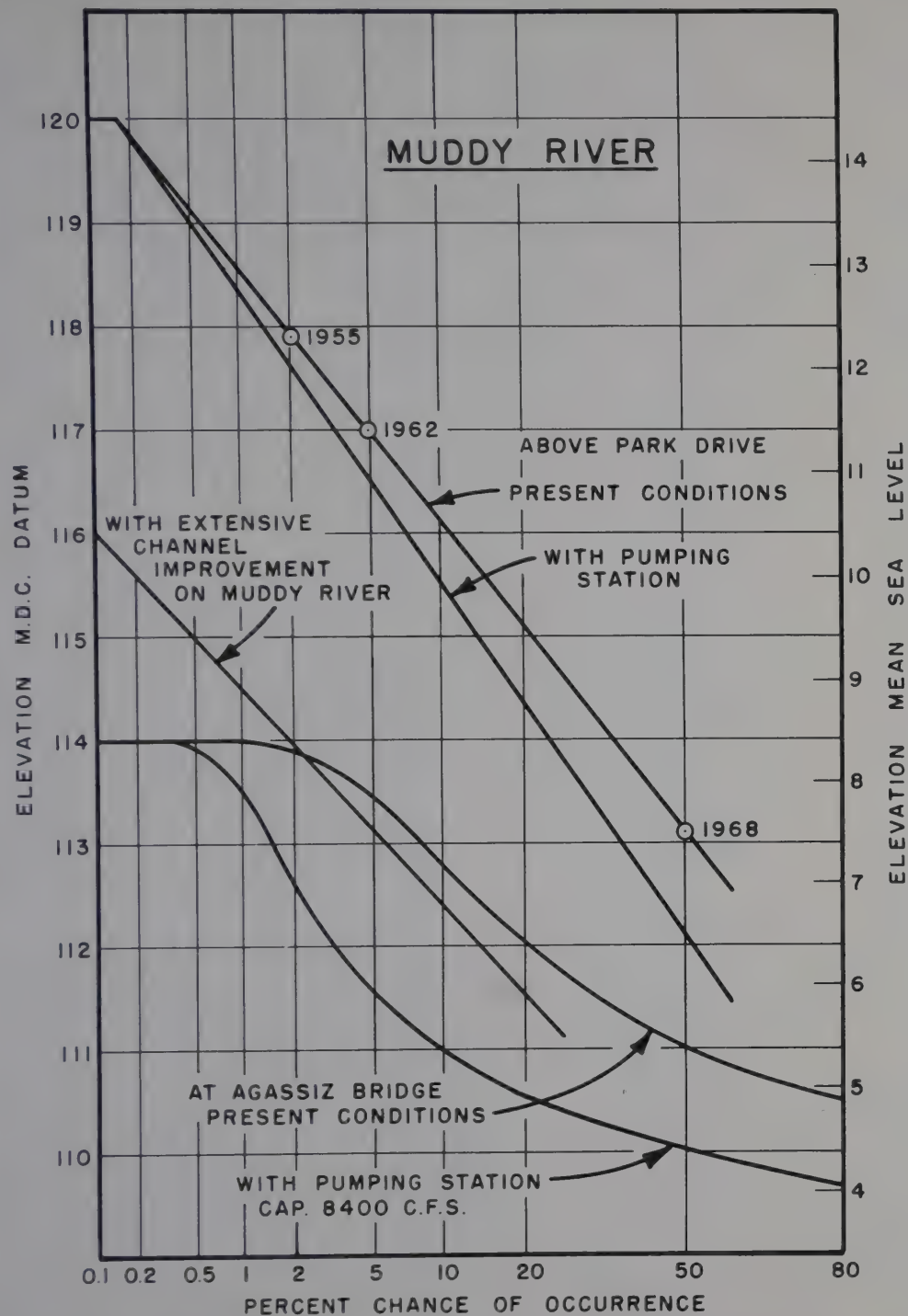
CHARLES RIVER INTERIM REPORT
LOWER CHARLES RIVER
FLOOD HYDROGRAPH OF
MARCH 1968

MAY 1968

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



CHARLES RIVER INTERIM REPORT
LOWER CHARLES RIVER
HIGH WATER ELEVATIONS
AND FREQUENCY OF OCCURRENCE
MAY 1968
 DEPARTMENT OF THE ARMY
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS
 WALTHAM, MASS.



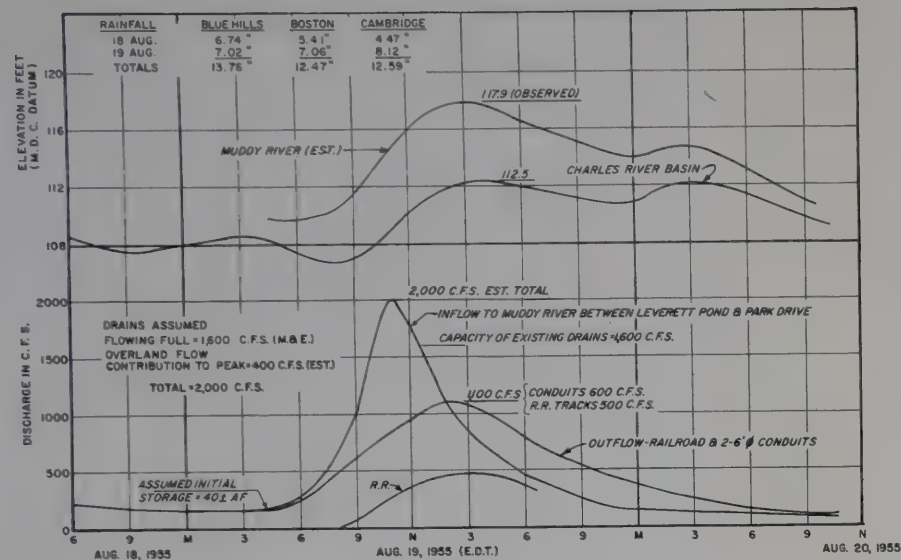
CHARLES RIVER INTERIM REPORT
LOWER CHARLES RIVER
ELEVATION-FREQUENCY CURVES

MAY 1968

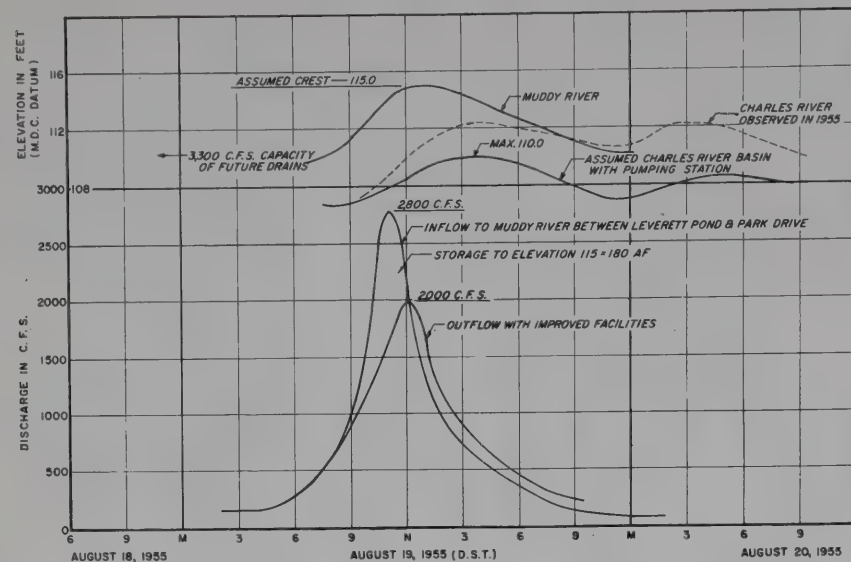
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NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



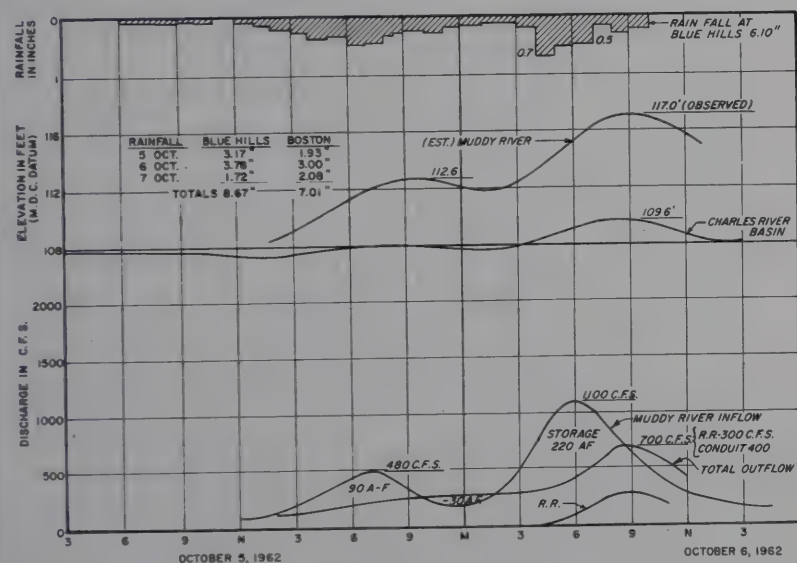
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS			
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER			
MUDDY RIVER PLAN AND PROFILE			
DES. BY	DR. BY	CH. BY	
REVIEWED: PROJECT ENGINEER			
REVIEWED: CHIEF, RIVER BASIN STUDY			
APPROVAL RECOMMENDED:		APPROVED:	
DATE: MAY, 1960		DATE: MAY, 1960	
TO ACCOMPANY REPORT DATE: MAY, 1960		SHEET	



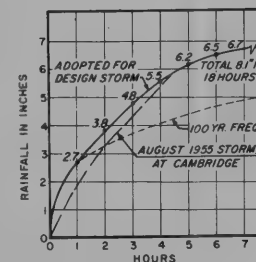
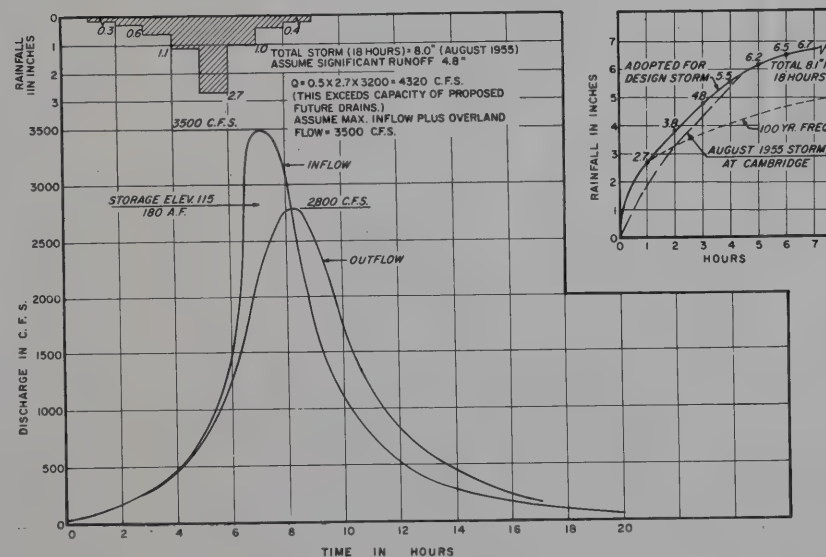
AUGUST 1955 FLOOD (1955 CONDITIONS)



AUGUST 1955 FLOOD WITH IMPROVEMENTS



OCTOBER 1962 FLOOD (1962 CONDITIONS)



DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.			
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER MUDDY RIVER FLOOD HYDROGRAPHS AUG. 1955, OCT. 1962, DESIGN FLOOD			
DES. BY	DR. BY	CH. BY	DATE
PROJECT ENGINEER			MAY 1966
REVIEWED:			
CHIEF, RIVER BASIN STUDY			MUDDY RIVER, MASSACHUSETTS
APPROVAL RECOMMENDED:			
CHIEF, PLANNING BRANCH			SCALE: SCALE AS SHOWN SHEET
TO ACCOMPANY REPORT DATED: MAY, 1966			

APPENDIX E

NAVIGATION

APPENDIX E

NAVIGATION

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APPENDIX E

NAVIGATION

1. INTRODUCTION

This Appendix reports current and prospective navigation usage of the Charles River Basin* and of the sole existing navigation lock in the Charles River Dam at Leverett Street, Boston. The lock affords passage between the Basin and Boston Harbor.

Also this Appendix demonstrates the derivation of substantial annual benefits estimated from the navigation improvements (new locks) proposed at Warren Avenue, Boston, and related changes at the existing Leverett Street lock, 2,250 feet upstream from the Warren Avenue site proposed.

Reporting only on Lower Charles navigation, this appendix necessarily is confined to the river reach below Watertown Dam.

2. EXISTING NAVIGATION WATERS AND FACILITIES

Charles River navigation occurs principally downstream of Watertown Dam, in the last ten miles of the River, see plate at end. In this reach of river are four yacht clubs (principally medium size power launches and cruisers); nine rowing clubs (three private, six school or college); two small-boat sailing pavilions with several club users; two trailer-boat-launching areas; and four designated public mooring areas.

Power-cruiser mooring clusters exist upstream on both banks in Watertown and Newton (between the former U. S. Arsenal and the Perkins Institution for the Blind) and downstream, along the Cambridge shore near Massachusetts Avenue, near the Broad Canal, and near the Lechmere Canal and Science Museum.

In between are the school and college rowing clubs, and the two sailing pavilions.

The two public boat launching areas are at Nonantum Road, upstream and at Magazine Beach, Cambridge, above the Boston University Bridge, downstream.

*The term "Charles River Basin", here as elsewhere throughout the Lower Charles Interim Report, refers exclusively to the 8.6 mile river impoundment upstream of and created by the Charles River Dam.

Navigating the tidal portion of the Charles between Boston Inner Harbor and the Basin currently entails passing through seven waterway constrictions, listed below:

LOWER CHARLES TIDAL NAVIGATION OPENINGS

<u>Constriction</u>	<u>Clear Width</u>	MSL <u>Clear Height</u> (closed)	<u>River Mile</u>	<u>Nature of Constriction</u>
Charlestown Bridge	50	28.4	0.66	fixed bridge, hwy
Warren Ave. Bridge	36	n.a.	0.76	damaged bridge, hwy
Fitzgerald Expwy	n.a.	55.0	0.79	high-level bridge, hwy
B&M R.R. Bridge	65	7	0.95	2 bascule leaves, rr
MBTA Viaduct	50	37.4	1.15	fixed bridge, rr
Leverett St. Bridge	50	10.4	1.16	2 bascule leaves, hwy
Chas. River Lock	45	n.a.	1.18	two roller gates, navig

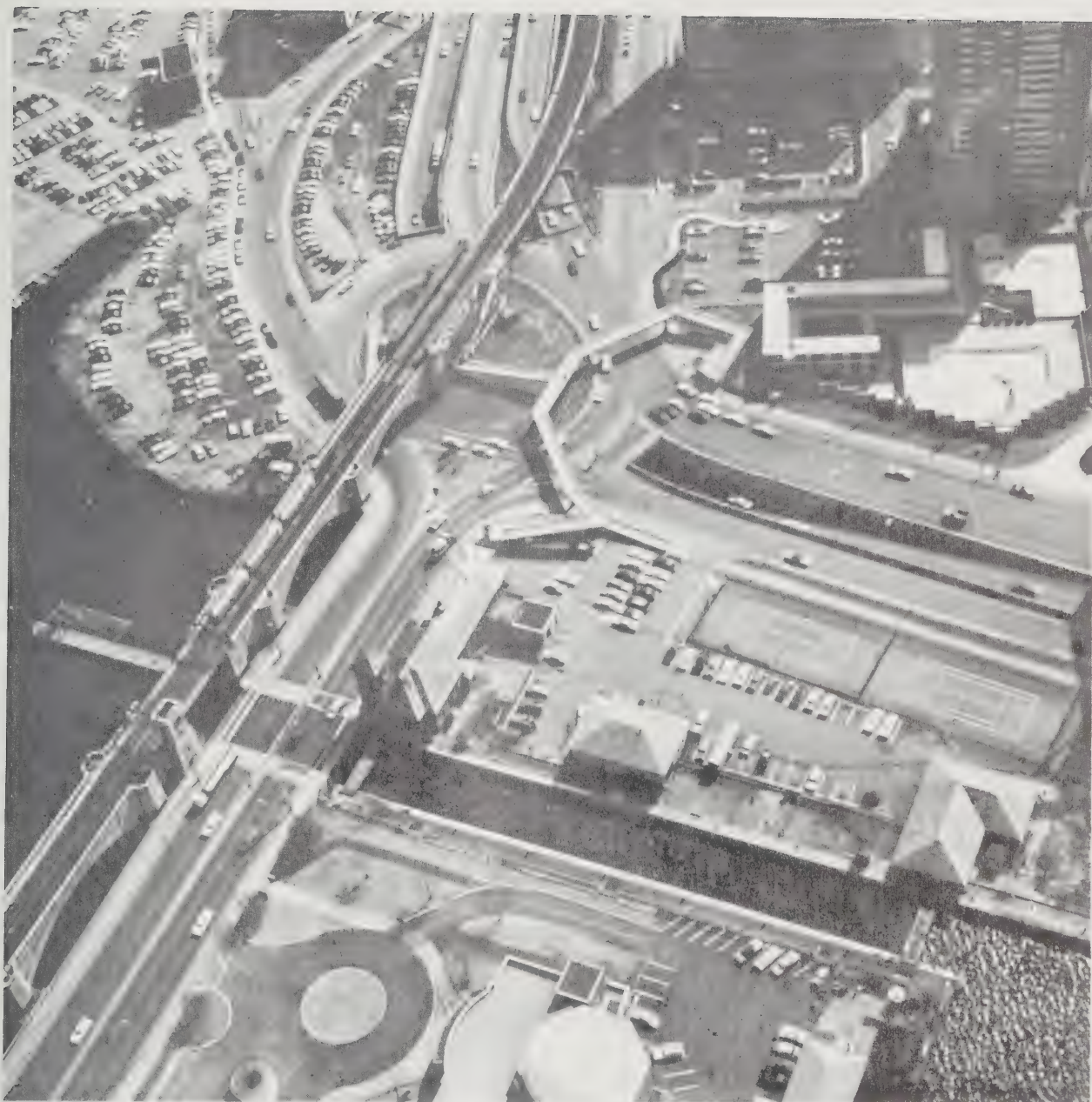
The constrictions which limit navigation in the tidal portion of the Lower Charles appear likely to be removed or enlarged in the next five years. The last of the four B&M R.R. bridges across the Charles is being supplanted by a M.B.T.A. transit tunnel extension under the Charles River. The former Warren Avenue bridge opening will be widened by the MDC under Ch. 550 of the Acts of 1962.

Reconstruction of the Leverett Street bridge over the lock was completed in June 1964, and operation mechanized. The new vertical clearance when closed, nearly double the prior clearance, has halved the number of bridge openings: see first column, Table E-1, page E-5.

On the Basin itself, waterway widths through main stem bridges are each 45 feet wide or more and each have 12' vertical clearance, or more, as tabulated below:

CHARLES RIVER BASIN NAVIGATION OPENINGS

<u>Constriction</u>	<u>Clear Width</u>	Basin Level <u>Clear Height*</u>	<u>River Mile</u>	<u>Nature of Bridge</u>
Longfellow Br	187	29	1.7	Subway & highway
Mass. Ave. Br	59	12	2.7	Highway
Former B&A R.R. Br	45	12	3.7	Freight & R.R.
Boston Univ. Br	170	12	3.7	Highway



EXISTING NAVIGATION LOCK AND LIFT-BRIDGE
(26 MARCH 1968)

CHARLES RIVER BASIN NAVIGATION OPENINGS (Cont'd)

<u>Constriction</u>	<u>Clear Width</u>	<u>Basin Level</u>		<u>River Mile</u>	<u>Nature of Bridge</u>
		<u>Clear</u>	<u>Height</u>		
River St. Br	45	12		4.5	Highway
Western Ave. Br.	45	12		4.7	Highway
John W. Weeks Br	45	12		5.1	Footbridge & steam pipe
Larz Anderson Br	45	12		5.3	Highway
Chas. W. Eliot Br	45	14		6.1	Highway
Arsenal St. Br	45	12		7.3	Highway
North Beacon St. Br	45	12		8.1	Highway
Galen St. Br	88	11		9.6	Highway

The one navigation lock in the existing (1910) Charles River Dam is 45 feet wide and 350 feet long. On the upstream (Basin) sill the water depth is 21.1 feet at Basin design water level, which is 2.4 feet above mean sea level. On the downstream sill of the lock - the tidal harbor sill - the water depth is 22.0 feet at mean sea level, and 17.4 feet at mean low tide.

A lock gate on rails rolls horizontally into the waterway on each sill, from a slot in the lock wall, at 90° to the lock wall. These gates cannot reliably be operated against any appreciable head. The water levels must be approximately equal each side before either gate can be operated in or out of its slot.

In operation the lock is filled and emptied exclusively by gravity water flow through five ports in each gate, electro-hydraulically operated. There are no filling ports or conduits in the lock walls or floor.

With stop-logs in place, when the locks are closed for repairs, the existing two lock de-watering pumps require some 8 hours to empty the lock.

3. COMMERCIAL VESSEL TRAFFIC

The existing Charles River lock must accommodate all commercial vessel and recreational boat traffic. In the 35 years since 1933, the traffic has shifted sharply from commercial to recreational.

Commercial traffic into the Charles River Basin via the lock reached a peak in 1926 when 7,505 inbound and outbound commercial vessel passages were reported, then declined to 2,056 vessel passages reported in

1933. In the period 1933 to 1961 (except the World War II years), commercial passages through the lock averaged some 2,000 per year. Between 1961 and 1967 commercial vessel passages declined further. Commercial vessel passages in 1967 were 576, even though the lock was closed in the months of October and November for repairs. Table E-1, page E-5, shows commercial passages through the lock in the years 1940-1967.

Although the commercial vessel traffic into the Basin has been decreasing, there are national security and research interests along the Basin below Massachusetts Avenue Bridge, that might warrant preserving and continuing the existing capability for barging in big magnets and heavy research and manufacturing equipment.

Former high wage costs for 24-hour bridge-opening staffs are no longer a major factor relative to commercial barging in the first 2.75 miles of the Charles River from tidewater at the U. S. Naval Shipyard to the Massachusetts Avenue Bridge.

The 1965 location on the Broad Canal, Cambridge, of the U. S. National Aeronautics and Space Administration research complex displaced several former commercial barge traffic users. Also, the N.A.S.A. location opened new reasons for not permanently closing the Basin to barges, and heightened the obligation to maintain the remaining commercial barging of heavy No. 6 fuel to the Cambridge Electric Light Co. plant on the Broad Canal. This plant, rebuilt in 1949, is both an electric generating station and a steam supply plant for heating and for manufacturing process use.

4. LOWER CHARLES LAND USE AND NAVIGATION

a. Main River. Commercial navigation all the way to the Galen Street Bridge, Watertown was once a reality. Schooners, barges and other craft went to Watertown Square, to the Watertown Arsenal, to the Boston Elevated Railway electric power station, to the Harvard University contract heating plant, to the Brookline Gas Works and to commercial establishments on the two canals and along the Cambridge shore.

Since 1910, the draw- and swing-bridges below Watertown Dam have one by one become fixed in place or rebuilt as non-opening bridges.

TABLE NO. E-1

CHARLES RIVER DAM, BOSTON
RECORDS OF LOCK USE AND BOATS

<u>Year</u>	<u>Drawbridge Openings</u>	<u>Lock Openings</u>	<u>Commercial Vessels</u>	<u>Recreational Small Boats</u>
1940	2,207	4,609	2,290	9,037
1941	1,998	4,128	1,954	8,218
1942	953	1,362	938	1,387
1943	376	511	413	364
1944	395	609	411	458
1945	1,030	1,843	837	2,633
1946	1,959	3,695	1,995	5,933
1947	2,341	3,837	2,749	6,959
1948	2,370	3,919	2,757	6,482
1949	2,066	3,776	2,390	6,568
1950	2,545	4,227	3,089	5,500
1951	2,822	4,403	3,426	5,719
1952	2,283	4,218	2,465	6,291
1953	2,113	4,114	2,405	5,795
1954	1,921	4,238	1,877	7,949
1955	2,122	4,743	1,780	10,106
1956	2,049	5,296	2,205	10,546
1957	2,264	5,740	2,083	14,434
1958	2,132	5,113	2,324	12,019
1959(1)	1,791	4,129	1,944	11,285 (1)
1960	2,242	5,277	2,312	14,320
1961	2,408	5,804	2,022	13,975
1962	2,223	5,470	1,485	14,723
1963	1,731	5,536	1,177	14,425
1964	845	5,464	850	13,298
1965	851	5,926	845	14,361
1966	855	5,645	807	14,130
1967(2)	654	5,307	576	12,650 (2)

(1) Locks closed for repair 4/21-6/27/59

(2) Locks closed for repair Oct. - Nov. 67

Sources: MDC records: 1967-1959, direct;
1958-1940, prior report of MDC consultant

Water delivery of coal to the Western Avenue Cambridge Electric Light Co. plant was maintained until coal was supplanted by oil and natural gas.

A substantial part of the former Arsenal is in the hands of General Services Administration for disposal.

The Boston Elevated power station at Larz Anderson Bridge became the site of Eliot House, Harvard College. The former Brookline Gas Works at River Street Bridge is now the Coca Cola bottling plant.

b. Broad Canal. Navigation into the Broad Canal, Cambridge, entails passage through a pair of 40 foot wide waterway openings, made by a pair of lift bridges in First Street and the MDC Parkway.

Much of the upper two-thirds of the Broad Canal, above Third Street, became filled during the years 1964-1967 to accommodate the U. S. National Aeronautics and Space Administration research complex, now under construction. The commercial property owners displaced chose other, non-Charles sites for relocation.

The remaining commercial user on the Broad Canal is the Cambridge Electric Company, which recently acquired the lease to the property of the Cambridge Gas Company. At Broad Canal, the Cambridge Gas and Electric Company received approximately 400,000 barrels of No. 6 fuel oil during 1967. Small, self-propelled tankers, once used to transport fuel oil to Charles River Basin locations, are no longer so used because the Charlestown Bridge, originally a draw-bridge, was made a fixed bridge in the 1940's.

Representatives of the electric company and the gas company state that their oil receipts will increase an average of 1 to 2 percent each year, keeping pace with population increases.

It is noteworthy that White Fuel was displaced from the Broad Canal at Third Street by market economics, not directly by N.A.S.A. Costs, difficulties and scale of petroleum products marketing made White ready to leave the Kendall Square Area. The building of Technology Square, the presence of M.I.T. and of N.A.S.A., and recent technological developments made E.B. Badger Mfg. Co. of Cambridge desire a site in that neighborhood.

White vacated in May 1967 for Badger. A high-rise office building complex is now under construction at the site.

The net navigation result is to remove a former commercial barge traffic generator, but to open two new canal use possibilities: (1) barging big machines or big components to the site; (2) new recreational boating demand on the canal by cruisers (or outboards) of Badger office and NASA occupants.

c. Lechmere Canal. The upper reaches of the Lechmere Canal, like the Broad Canal, have been filled in recent years to make larger, more usable parcels of land, in response to increasing economic demands for building development in this area. A fire in a large older building, a change in a corporate name, and processing and marketing economics brought about the departure of two or three commercial barge users from the Lechmere Canal. The presence of M.I.T., N.A.S.A., the new high-rise Middlesex County Courthouse, Science Museum expansion and consequent M.D.C. relocation all provided immediate, competitive re-use for lands on the canal.

The Boston Sand and Gravel Company relocated its operations some 2,500 feet distance from the Lechmere Canal to a Boston and Maine Railroad site on the Miller's River, upstream of the proposed Warren Avenue Dam. This company, which required some 500 lockings in and out per year prior to 1962, is now served entirely by railroad and truck.

The former California Oil petroleum products distribution property on the Lechmere Canal is now occupied by Chevron Oil Co., which in 1967 received at this site, 123,000 barrels of #2 household heating oil.

5. RECREATIONAL BOATING

Recreational boating on the Lower Charles River in any large numbers of boats or persons is mainly in the Basin, which is the 8.6 mile level reach between the Charles River Dam and Watertown Dam. The reach next upstream, between Watertown Dam and Moody Street Dam, Waltham, has not attracted boating because of a 27-foot fall, two intervening dams, limited access and former industrial pollution.

The protected, level, 8.6 mile Charles River Basin has superlative attractions for oarsmen, sailors and power boat operators.

There have been traffic problems and conflicts between the various rowing, sailing and power boat users. However, local moves are being made to create a forum of river users to help guide the development of a long range plan for boating traffic on the Basin.

Lower Charles recreational boating since 1945 has increased mainly in power boating and in sailing. Rowing has increased by the establishment of two new school and college boathouses.

On the Basin are three private rowing club boathouses with combined 1967 total of some 100 sculls, 20 shells and 3 or more launches.

Also on the Basin are six school and college rowing boathouses with combined total boats in 1967 as follows: sculls, 84; shells, 106; launches, 25 or more.

On the Basin are the Community sailing pavilion and the M.I.T. sailing pavilion, used also by Harvard and by Boston College. B. U. sails from its own boathouse and Emerson College from a float upstream of Union Boat Club. In 1967, the combined total sailboats numbered 140 or more.

Also on the Basin are four private yacht clubs with 205 powerboats in 1967, and 70 or more outboards, plus dinghies and other small craft.

The 1967 Charles River Basin resident boat totals by broad types were: Rowing, 345; Sailboats, 145; Powerboats, 310, in yacht clubs, plus 200 at the four public mooring areas (see attached plate).

In addition, large numbers of trailered boats are launched for day use from the MDC Magazine Beach and Nonantum Road launching and parking areas. No reliable count is kept, but 250-300 on weekends have been estimated, and more on the two long summer holidays.

All told, there are an estimated 1,500 power boats, sailboats, and rowboats based in, trailered to, or visiting the Basin. Of this number, approximately 800 are outboards and power cruisers which use the Charles River Dam lock.

6. RECREATION BOAT LOCK TRAFFIC

Pleasure boat traffic through the lock fluctuated between 1,400 and 3,500 passages per year in the early Basin years, 1910 to 1932. Then



LOWER CHARLES RIVER BASIN SAILING
MAY 1968



UNIVERSITY ROWING, LARZ ANDERSON BRIDGE
MAY 1968



NEWTON YACHT CLUB ANCHORAGE
MAY 1968

pleasure boat passages rose steadily to 1941, when some 8,200 passages were reported. Pleasure boat traffic through the lock diminished in war years to some 1,500 to 500 annually. From 1946 on, the number of pleasure boat passages increased again, and has ranged 12,000 to 14,000 per year throughout the years 1956-1967. Twelve thousand, six hundred and fifty (12,650) in and out passages were recorded during only ten months of 1967, when the lock was closed two months for repairs and replacements. From sample counts, it has been estimated that 44% of all pleasure boats passing through the one existing lock are outboards.

Existing peak pleasure boat traffic occurs on weekends in June, July, August, and September, when the number of boats being locked approaches 500 per day. The critical times of lockage on peak days are 10:00 A.M. to 8:00 P.M., a 10-hr. period. Some boats experience long delay, if they just miss a locking. Existing locking capacity at the Charles River lock is about 70 boats per hour in one direction, and results in congestion during peak use.

7. PROSPECTIVE RECREATIONAL BOATING

Even with existing locking capacity and locking time, some increase in recreational boat passages will be realized in future years. This increase will be moderate as the existing locking facilities do not conveniently accommodate existing numbers of peak daily passages. It is estimated that the numbers of pleasure boats passing through the existing lock will rise from the current range of 14,000 or so each year to about 20,000 per year.

Two or more new locks at the Warren Avenue site would provide increased locking capacity, faster acting lock gates, and faster rates of filling and emptying of locks both with boats and with water. Also dam construction at Warren Avenue would create some 45 acres additional pool area between the existing and proposed dams, offering excellent potential for marina development.

It is reasonably expected that these features would result in an increase in annual recreational boat passages from the present average of 14,000 to about 40,000 by the end of the navigation economic life, 50 years. This increase would result partly from an increase in the number of boats and partly from an increase in the number of trips per boat.

Local interests will preserve and maintain all present openings--the lock and the sluice gates--through the existing Charles River dam to assure continuing water flow and unrestricted boat passage. With lock gates removed, the 45-foot wide canal will freely pass all existing and anticipated recreational boats. Commercial traffic occurs weekdays, mostly nights and early mornings, when pleasure boating is light.

The estimated increase with new locks at Warren Avenue would be 40,000 less 20,000 expected without improvement, or 20,000 passages per year net addition with improvement.

To handle any appreciable increase in recreation boat passages through the existing lock will require either re-equipping the existing lock and building another alongside it (which would entail two more new bridge leaves) or wholly new locks at some other site. A new locking site is a necessity. It is physically and financially impractical to attempt enlargement or additional lock construction at the existing (1910) Charles River Dam.

8. RECREATION BOAT LOCK SIZE REQUIREMENTS

New Locks must provide for future recreational boat traffic. Lockage of the order of 14,000 boats per annum has prevailed the last twelve years. Doubling over the next 50 years (an increment of 2% per year) is a reasonable minimum expectation, and tripling perhaps a maximum.

The existing diffusion of real personal income and real leisure in eastern U.S.A. appears likely to continue, if not increase, in the next half century, especially in the Megalopolis and in metropolitan Boston. Thus, an increase of 1,550 additional power boats (1,200 Basin based, 350 equivalent trailered boats) is estimated. The 1967 existing equivalent fleet is some 1,000 boats using the lock, Table E-2, page E-18.

The current numbers of power boat passages through the existing lock (about 500 per day on the ten or more peak days per season) may be expected to increase sharply after completion of the proposed new locks. An increase by half in five years; doubling the 1967 numbers in 25 years, and tripling them during the second 25 years of the navigation project life is estimated. This essentially constitutes accelerated growth.

The existing Charles River lock congestion is experienced in the ten hours 10:00 A.M. - 8:00 P.M. of the seasonal peak days, making some 500 boat movements. However, the boats requiring lockage do



CHARLESGATE YACHT CLUB PIER
CLOSE TO SCIENCE MUSEUM, CAMBRIDGE SIDE
MAY 1968

not come at smooth average of 50 per hour, but cluster in peaks such that there is congestion and delay even when the lock is moving 70 boats per hour. Accordingly, the number and size and operation of new locks will provide a locking rate not less than 140 boats per hour in the main direction of boat travel at the new Charles River Basin outlet. Plans to provide for these recreation boating needs are discussed in the following paragraphs. Also discussed is the feasibility of excluding commercial traffic from the Charles River Basin.

a. Lock width. To provide the necessary locking facilities for the existing and prospective recreational fleets, an investigation was made of the numbers and composition of these fleets. The largest boat expected to use the basin in the future will have a beam of 20 feet. The beams of pleasure boats seldom exceed 14 feet. The average beam of pleasure boats using the basin lock is 9 to 10 feet. The national average is 6 to 7 feet but boats passing to use the ocean tend to be larger. Allowing a 10-foot width within a lock for an average size boat, with 5 additional feet for clearance between the boats and floating moorings at lock walls, a total width of 25 feet would be necessary in order to accommodate two rows of craft. During normal lockings, it would not be unusual that larger than average size boats with beams up to 12 feet frequent the lock. The remaining 10-foot space would allow an 8-foot boat to pass by or to be locked adjacent to the 12-foot boat. A similar situation applies if boats of 14-foot beams use the locks. A craft with a 15-foot beam is unusual. Lock widths of 20 feet or 24 feet, with allowances for proper clearances, would result in wasted space due to difficulty in locking differing sizes of craft. Therefore, a lock width of 25 feet is considered optimum.

b. Lock sill depth. The average draft of the prospective fleet that will use the locks is estimated to be four feet with the draft of the largest vessel approximately 8.5 feet. A 6-foot depth over the lock sills at low water would accommodate most pleasure boats. An allowance of one foot under the keel would permit a boat drawing five feet to be locked. A 5-foot depth would be insufficient for many craft and a 7-foot depth would not permit enough additional craft to pass to justify the added lock cost. The relatively few pleasure cruisers and auxiliary sailboats drawing in excess of six feet would be able to use the commercial lock. Thus, the most practical depth is six feet at low water.

c. Lock length and number of locks. The length and number of locks, assuming two rows of boats per lock, must be based upon future recreational boat traffic. The length of the average boat using the lock, with allowance for two feet of clearance per boat, is about 35 feet. Hence, the total space occupied in a lock by the average boat is 35×10 , or 350 square feet. During weekdays, the pleasure boat traffic is comparatively

light. However, during the peak days of traffic, which occur on weekends in June, July, August and September, the number of boats being locked approaches 500 per day. Based on the expected increase of nearly three times, the total number of future boat passages would be nearly 1,500 per day, expected to occur by the end of 50 years after improvement. The critical periods of lockages on peak days are 10:00 A.M. to 8:00 P.M., a 10-hour period. Thus, a locking rate of about 150 boats per hour is recommended. The existing locking capacity at the Charles River lock of 70 boats per hour in one direction results in congestion during peak use.

For a 200-foot long lock, the number of craft that could be locked at one time would be 12, six in each of two rows ($35 \text{ feet} \pm \times 6 = 200 \text{ feet}$). The average locking time would be about 20 minutes per cycle. A cycle is expected to consist of loading a full lock-load of boats in the peak direction of travel, filling or emptying the lock depending on whether the direction is in or out of the basin, unloading these craft, then reversing the procedure but with only one or two craft expected to require passage in the non-peak direction. Thus, one lock would allow 3×12 , or 36 boats per hour, which would be far from adequate for even present traffic. Two locks of 200-foot length would allow for 72 boats per hour, which would represent about one-half of the expected peak passages. The total area of the existing lock is nearly 16,000 square feet and substantial delays are already being experienced with existing conditions. A third small boat lock of similar dimensions would still not provide for peak needs. Doubling the length of two locks to 400 feet each would not double the locking capacity per hour as the loading and unloading times of boats in the locks would be proportionately greater, as would the filling and emptying rates of the locks. A logical alternative appears to be to provide a combination lock to supplement two 200-foot long by 25-foot wide pleasure boat locks. The combination lock would be used jointly by commercial vessels, even though traffic by these vessels is not nearly as great as in past years, and by recreational craft on peak days, including those whose heights and drafts are too excessive for the small boat locks. The present and expected future use by commercial vessels and the need and justification for a commercial lock are discussed below.

Two new 200-foot long recreation boat locks of 25 feet width and 6 feet low-water depth would provide 72 or more boat capacity per hour on one-third less cubic feet of water per cycle of the two small locks than one cycle of the existing lock.

The two new locks would sharply reduce salt water intrusion into the Basin because of tighter gates and lock operation by pumping out when lowering.

To assure all needed boat passage capability throughout the 50-year navigation project life, the two small recreation boat locks will be supplemented by one longer, wider, deeper commercial boat lock, likewise operated by pumping discussed below.

9. COMBINED COMMERCIAL VESSEL AND SMALL BOAT LOCK SIZE REQUIREMENTS

In 1967 there were a total of 576 trips of commercial vessels into and out of the basin, mainly trips to and from the Cambridge Electric Company along the Broad Canal, to the Chevron Oil Company on the Lechmere Canal and a few trips by work barges and excursion boats. The types of vessels used in carrying oil to these two oil terminals were steel tank barges towed by tugs.

The length of the barges used in recent years ranged from 120 to 165 feet; the beams from 22 to 34 feet; the loaded drafts from 9.0 to 12.6 feet. The tug lengths varied from 55 to 69 feet; the beams from 17.5 to 20 feet; the drafts from 6.7 to 9 feet. Thus, the following dimensions appear to be the maximum required: Length - 165 feet (barge) and 69 feet (tug), or 234 feet; width - 34 feet; depth - 12.6 feet.

A major oil transportation company of the Charles River and Boston Harbor area indicates that tugs are being built with lengths of 85 feet, barges with lengths to 204 feet, and beams to 39 feet. The maximum barge draft is 17 feet loaded, but these barges are more commonly loaded only to 14 feet draft for towing and maneuvering reasons.

Accordingly, it is considered that a lock 300 feet long, 40 feet wide and having a water depth over the sills of 15.0 feet at low water conditions would provide for all tug-barge combinations without difficulty. These

dimensions would allow proper clearances to prevent damage to vessels by turbulence during filling and emptying the lock.

A commercial lock 300 feet long by 40 feet wide could accommodate 35-40 pleasure craft per cycle, with about two cycles per hour, thus moving additional 70 boats or more per hour. Such a commercial lock would adequately provide for commercial movements and for supplemental locking of small craft on peak days.

10. ALTERNATIVES TO COMMERCIAL LOCK

The possibility of wholly excluding commercial traffic from the Basin presented itself in view of the declining Charles River waterborne commerce. If no commercial lock were provided, the two most practical methods of transporting oil to the Cambridge Electric Company and the Chevron Oil Company would be (a) pipeline or (b) trucking.

There is now no rail access to either terminal facilities, and provision of rail access through the existing dense commercial and industrial areas would be prohibitive. Also their oil now arrives at Boston Harbor in large bulk carriers by water.

a. Pipelines. All of the oil used by the electric company is No. 6 oil, sometimes called bunker "C" oil, burned in the production of electrical energy. Because of the high viscosity of this oil, it can only be pumped through short lengths of unheated pipe. To permit pumping No. 6 oil longer distances, the pipelines would have to be heated. This would require one pipe concentrically placed within a second pipe of larger diameter with steam forced between the two pipes for their complete length. The annual costs for 1.67 miles of steam-heated pipeline and construction of a pump and heater installation along the line, would be about \$200,000.

Another pipeline about 1.3 miles in length would have to be built to Chevron Oil Company on Lechmere Canal. This line would not have to be heated as the oil involved is a No. 2 heating fuel with relatively low viscosity. The annual charges for this pipeline are estimated at \$100,000.

Total annual charges of \$300,000 for the two pipelines do not include any charges for right-of-way costs, which would be very high.

No estimate for right-of-way charges was made as the annual costs of \$300,000 for the pipelines alone would far exceed the annual costs for a commercial lock of a first cost around \$3 million dollars and 50-year life.

b. Trucking. Consideration was given to using trucks to transport the oils to the basin terminals, for both present and prospective needs. It was found that trucking of the No. 6 oil to the Cambridge Gas & Electric Company from its supplier near the mouth of the Chelsea River, using 5,000-gallon capacity semi-trailers, would entail an additional cost for oil and labor of approximately \$80,000 per year. This cost is based on current receipts of about 400,000 barrels per year. The company estimates that its oil requirements, which are directly related to population and commercial and industrial growth, will increase at an average rate of one to two percent per year. Assuming a straight line growth over a navigation project life of 50 years, and assuming an average yearly increment of 15 percent, there would be 300,000 barrels of additional oil receipts at the end of that period, i. e. 75 percent of existing barrel receipts per year. The cost for trucking the additional 300,000 barrels would be \$60,000. The average annual equivalent charge over a 50 year period would be $\$60,000 \times 0.382$ or \$22,900.

Similarly, trucking approximately 123,000 barrels (current quantities) of No. 2 oil to Chevron Oil Company would be about \$25,000 per year. This company also indicates a 1 to 2 percent yearly average increase. Assuming 1.5 percent annual increment over the 50 year project life, there would be 92,000 barrels additional oil receipts by the end of that 50-year period.

The attendant trucking costs would be \$18,700 with average annual charges of $\$18,700 \times 0.382$ or \$7,100 per year.

Thus, the total annual costs attributable to the use of trucking as an alternative means of transporting oil into the basin are \$135,000. These annual charges, based on a 50-year life, would exceed those for a commercial lock.

The electric generating company is concerned over the possible difficulties of maintaining an adequate, constant fuel supply during winter weather when peak demands would necessitate about 600 truck deliveries per month.

A commercial lock will provide for the passage of recreational craft of draft or beam too great for the small boat locks, also for the passage of lighters and work barges expected to be required in the basin in the future to construct, reconstruct and repair bridge, bulkhead, pier or marina and related shorefront facilities.

11. ESTIMATE OF BENEFITS

a. Commercial Navigation. No commercial navigation benefits are to be realized since there is an adequate existing commercial lock. A need and economic justification for a new commercial lock has been established. Therefore, the construction proposed merely transfers the commercial lock from one site to another.

While the new commercial lock will be equipped with pumps and faster acting gates, the commercial vessel time saved per year will be small, in view of the modest number of commercial lockings per year currently anticipated.

b. Recreational. The need for two small boat locks and a larger commercial-recreational lock have been established. Now it is necessary to determine the benefits derived and the proper allocation of these benefits to each purpose.

The locks will be equipped with pumps and with modern gates and floating moorings. This will considerably reduce locking time compared to operations at the existing lock.

The proposed dam will create a new, constant water level in 45 acres water area in the 2,250-linear feet between the proposed dam and the existing dam. This area could provide extensive marina and related boating facilities. In addition, in times of severe storms it is anticipated that boats not normally moored in the basin would come through the fast-operating locks into the newly created basin for storm refuge.

There are approximately 18 organizations for recreational boating on the Charles River Basin with a total of some 1,500 boats. Of these 1,500, about 800 use the Charles River Lock. In addition to the 800 craft berthed in the basin, there are large numbers of trailered boats launched during the summer months at several sites

along the basin. These trailered boats are estimated to be equivalent in number to 100 or more permanently based craft. The trailered boats which are all powered, use the lock. Additional non-powered boats such as rowboats, sailboats, canoes, etc. seldom or never use the locks.

On a "for hire" basis, it is estimated that increased recreational boat use in the amount of 15 percent per boat would be realized as a result of the modern fast acting locking facilities. Further, the improved basin water conditions between the existing and proposed dams and upstream of both dams will attract 100 or more boats from areas in nearby Boston Harbor which are slightly less attractive or less adequately accommodated. Total benefits of \$65,000 would accrue to the 800 basin-based boats, the 100 equivalent trailered boats and the 100 transferred craft. It is presumed the latter craft were transferred because of the new facilities. Table 2 shows the derivation of these benefits, all of which constitute immediate benefits to be expected within a reasonable time after improvement.

As previously discussed, reduced commercial use of the basin, new boating regulations and controls, additional basin area, expected new launching sites and new marina facilities will permit and encourage some 155% increase of the number of lock-using boats, as shown

in Table E-2, page E-18. No additional transferred boats are anticipated in the future. Many of the expected new boats will be added to the basin during the early years of the 50-year navigation benefit life thus approximating accelerated growth.

The total benefits expected to accrue to these new recreational boats as they are added amount to \$598,800 at the end of 50 years. The average annual equivalent benefits are $\$608,800 \times 0.686$ or \$418,000. The benefits analysis is shown in Table E-2, page E-18.

As previously pointed out, the number of recreational boat passages would increase by some 6,000 annually as a result of a combination of an increased number of boats and an increased number of passages per boat, even without improvements. However, this would amount to only about 43 percent increase over the 14,000 annual recreational lockage of the 1960's.

CHARLES RIVER BASIN

TABLE E-2 BENEFITS TO RECREATIONAL BOATING

Existing basin fleet (800 boats), equivalent transient trailer fleet (100 boats) and transferred fleet (100 boats)

TYPE OF CRAFT	LENGTH (feet)	No. of Boats	DEPRECIATED VALUE		PERCENT RETURN				ON CRUISE			
			AVERAGE \$	TOTAL \$	Ideal	% of Ideal Pres.	Fut. Gain	VALUE \$	Avg. Days	% of Season	Value \$	
Outboards	10-20	450	1,600	720,000	14	85	100	2.1	15,100	--	--	--
Cruisers	15-30	300	5,000	1,500,000	9	85	100	1.4	21,000		10	2,100
	31-50	250	10,000	2,500,000	9	85	100	1.4	35,000		12	4,200
TOTALS		1,000		\$4,720,000					\$71,100			\$6,300
<div>\$71,100 - \$6,300 = \$64,800 - Say \$65,000</div> <div>Prospective additional basin fleet (1,200 boats) and equivalent transient trailer fleet (350 boats):</div>												
Outboards	10-20	800	1,600	1,280,000	14	0	100	14	179,200	--	--	--
Cruisers	15-30	425	5,000	2,125,000	9	0	100	9	191,300		10	19,100
	31-50	325	10,000	3,250,000	9	0	100	9	292,500		12	35,100
TOTALS		1,550		\$6,655,000					\$663,000			\$54,200

Prospective additional basin fleet (1,200 boats) and equivalent transient trailer fleet (350 boats):

Outboards	10-20	800	1,600	1,280,000	14	0	100	14	179,200	--	--	--
Cruisers	15-30 31-50	425 325	5,000 10,000	2,125,000 3,250,000	9 9	0 0	100 100	9 9	191,300 292,500		10 12	19,100 35,100
TOTALS		1,550		\$6,655,000					\$663,000			\$54,200

$\$663,000 - \$54,200 = \$608,800$
Average Annual equivalent = \$608,800 x 0.686 = \$417,600 . Say, \$418,000 annually

With improvements, the estimated increase would be from 14,000 passages to 40,000 annual passages, or 186 percent. By direct proportion the benefits expected without improvements would be \$418,000 x 43/186 or \$95,000 annually. Thus, the net benefit from increased boating with improvements would be $\$418,000 - \$97,000$ or \$321,000 annually.

The 45 acres newly created basin area between the proposed dam and the existing dam will provide a safe haven for craft navigating exposed areas of Boston Harbor during severe storms. Benefits attributable to this refuge are estimated at \$10,000 annually.

12. TOTAL NAVIGATION PROJECT BENEFITS

The total annual benefits on a 50-year navigation project life are \$396,000 as follows:

Increased use of existing recreational boats	\$ 65,000
New recreational boating	321,000
Harbor of Refuge	<u>10,000</u>
	\$396,000

Spread over 100 years, these benefits would be \$329,000 annually.

APPENDIX F

PROJECT DESCRIPTION

AND

COST ESTIMATES

APPENDIX F
PROJECT DESCRIPTION
AND
COST ESTIMATES

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PERTINENT DATA

WARREN AVENUE MULTI-PURPOSE DAM

CHARLES RIVER, BOSTON, MASSACHUSETTS

<u>Purposes</u>	Flood Control, Navigation & Highway Transportation
<u>Location</u>	On Charles River, 2250' down- stream of the present Charles River Dam.
<u>Drainage area</u>	307 square miles
<u>Pumping station</u>	
Structure	Reinforced concrete, 85x184 feet
Pumps, number & capacity	6@ 1400 cfs = 8,400 cfs
<u>Navigation Locks</u>	
Commercial and recreational	One
Length - feet	300
Width - feet	40
Basin sill elevation - feet, msl	-14.62
Tidal sill elevation - feet, msl	-19.62
Recreational only	Two
Length - feet	200
Width - feet	25
Basin sill elevation - feet, msl	-5.62
Tidal sill elevation - feet, msl	-11.62

PERTINENT DATA (Cont'd)

Gates

Type	Sector
Top elevation - feet, msl	11.38

Dam

Type	Earthfill, rock slope protection
Top elevation - feet, msl	12.4
Maximum height - feet	36, above riverbed

Viaduct

Length - feet	700
Width - feet	61½ (4-lanes)

EXISTING CHARLES RIVER DAM AND BASIN (elevations in feet, mean sea level)

Top of dam (Roadway)	15.0
Top of downstream lock gate	10.4
Design basin level	2.38
October 1962 basin level	4.0
September 1954 basin level	4.9
March 1968 basin level	5.2
August 1955 basin level (Maximum recorded)	6.9

PERTINENT DATA (Cont'd)

BOSTON HARBOR
(elevations in feet, mean sea level)

Highest tide of record (1)	10.1
Spring tide	6.8
Mean high tide	4.9
Mean low tide	-4.6
Highest tide, modern record (2)	9.3

(1) Storms in April 1851 and December 1909

(2) December 1959

APPENDIX F

PROJECT DESCRIPTION AND COST ESTIMATES

INTRODUCTION

1. This appendix presents design features and cost estimates for the recommended plan for a multiple-purpose project consisting of a dam and appurtenant facilities at the site of the former Warren Avenue bridge across the Charles River between Boston and Charlestown, Massachusetts. The principal features of the plan are shown on Plates Nos. F-1 through F-4. The design and cost estimates for the selected improvement are based on detailed planning accomplished by a consulting-engineering firm for Metropolitan District Commission.

DESIGN CRITERIA

2. FLOOD CONTROL

The dam and pumping facilities have been designed to limit the rise of the basin to elevation 3.9 msl, about 1.5 feet above the normal pool elevation of 2.38 msl, with a peak inflow of 15,500 cfs and tide peak at elevation 7.4 feet above msl. The tide in the river below the dam ranges, on the average, from 4.6 feet below to 4.9 feet above mean sea level, a mean range of 9.5 feet. A high spring tide reaches about 6.8 feet, msl, and storm tides will range from about 9.3 to 10.1 feet, msl, the former, reached in December 1959, being the highest of modern record.

3. NAVIGATION

The navigation features, in the nature of locking facilities, have been designed to accommodate the largest vessels and barges now utilizing the Basin and to provide additional locking capacity to pass peak pleasure boat traffic.

4. HIGHWAY TRANSPORTATION

The highway viaduct has been designed to provide additional vehicular access between Charlestown and Boston and relieving the

traffic congestion at City Square, Charlestown. Present traffic volume in City Square is about 44,000 vehicles per day.

DESCRIPTION OF PLAN

5. DAM

The dam crossing the Charles River at the site of the former Warren Avenue Bridge between Boston and Charlestown, will be of earth fill with rock slope protection. It will have a length of approximately 750 feet; however, about 400 feet of this length is occupied by three navigation locks and a pumping station. The dam will have a maximum height of about 36 feet above the bed of the river and a top elevation at 12.4 feet, msl.

6. PUMPING STATION

A high-capacity, low head, pumping station with six (6) diesel pumps, each with a capacity of discharging 1,400 cfs at a 9-foot static head and not less than 1,260 cfs at an 11-foot static head, is proposed. The pumping capacity of 8,400 cfs will limit the rise of the basin to about 0.7 feet above normal level, to elevation 3.1 feet, msl, for a recurrence of the August 1955 flood. The normal basin elevation is 2.38 feet, msl.

The pumping station is located on the Charlestown side of the river. Heavy rock slope protection is provided at the intake and discharge ends to prevent scouring; a fender system at the discharge side is designed to prevent damage to the existing Charlestown bridge and to divert discharge flows past the locks:

Operation of Station. When severe storms are predicted the basin will be lowered in expectation of runoff which can develop very rapidly from the local urban areas. This drawdown will lower the basin elevation by one foot, to elevation 1.38 msl, by gravity sluicing. As the basin elevation begins to rise and sluicing is inadequate or not possible, one or more pumps will go into operation and remain on until sluicing can again be effective.

7. NAVIGATION LOCKS

Three locks are provided through the dam. One, 40 feet wide by 300 feet long, is designed to accommodate commercial

vessel traffic now utilizing the basin above the dam. Two, each 25 feet wide by 200 feet long, are provided to afford passage for recreational boats. The large lock would also be used by recreational craft on weekends and holidays, when necessary to supplement the capacity of the small boat locks. Appendix E, Navigation, discusses the decreasing importance, in recent years, of commercial vessel traffic, the increasing importance of pleasure boat traffic in the Charles River Basin, and the factors affecting the sizing of the locks. By providing two small recreational locks and a large dual-purpose lock, two-way traffic will be possible.

The design and operation of the locks will keep salt water intrusion to a minimum by providing the following features:

- a. Tight seals at the edges of the sector gates.
- b. High sills in the small locks will prevent the heavier salt water from filling the lock and will reduce the loss of fresh water from the Basin.
- c. Low intake on basin side to siphon existing salt water.
- d. Split sector gate in large lock (a dutch-door arrangement) to be opened only if draft of vessel demands depth.
- e. Pumps for dewatering in addition to gravity sluicing. These pumps will be used when tide is higher than the basin level and a vessel is passing from harbor to basin. The higher water in the lock will be pumped into harbor rather than sluiced into basin.

Rapid acting sector gates will allow for 36 boat passages per hour for each of the small locks. Floating mooring timber on the sides of these locks will enable boat owners to secure their own boats, thereby effecting a further savings in passage time.

8. HIGHWAY TRANSPORTATION

A highway viaduct would be constructed, approximately 700 feet long, between abutments located near the existing abutments of the former Warren Avenue Bridge. It would consist of eleven spans of reinforced concrete slab and steel stringer deck. The longest span would be approximately 80 feet long. The proposed roadway would be 52 feet wide, curb to curb, for four traffic lanes. A sidewalk and a safety walk would be provided, making the overall

width 61.5 feet. The approach grade on the Charlestown side is 3.00% and 4.80% on the Boston side. The vertical clearance at centerline of the large lock is 26.3 feet at mean high water; 28.8 feet above the normal elevation of the basin.

9. FISH LADDER

The estimate includes costs of \$10,000 for a fish ladder, to be located between the pumping station and the large lock. This cost is the net result of the savings in concrete, greater forming costs and addition of mechanical equipment.

LANDS AND DAMAGES

10. The cost of furnishing necessary lands, easements, and rights-of-way, which would be one requirement of local cooperation, has been estimated on the basis of a field examination of the project site and the application of current market values for real estate in the locality. Approximately four acres of land, of which about one-half is comprised of river flats and the remainder mainly filled land, will be acquired in fee. Temporary easements will be secured on nearly two additional acres of filled land for the period of project construction.

RELOCATIONS

11. MODIFICATIONS TO SEWERAGE AND DRAINAGE FACILITIES

The present comprehensive sewerage and sewerage disposal program for the lower Charles River area includes a pumping station, with a capacity of 140 million gallons a day, located at the outlet of the Boston Marginal Conduit approximately 400 feet downstream of the existing Charles River dam. The cost of this facility (\$1.5 million) is not included in the project cost.

In order to assure the same water quality in the extended basin as in the existing basin, discharges from the Boston Marginal Conduit together with the flows of the Cambridge Marginal Conduit and other sewer overflows in Charlestown now contributing to this portion of the river will be collected and discharged to the harbor, below the new dam. The work would include provision of (1) an eight-foot force main conduit extension from the Boston Marginal

conduit pumping station to the new dam, (2) a seven-foot sub-aqueous conduit connector between the Cambridge Marginal Conduit and the Boston Marginal Conduit pumping station, (3) relief sewers in the Charlestown area to eliminate overflows to the river, and (4) enlargement of the Boston Marginal Conduit from a capacity of 140 to 300 million gallons a day. See Plate No. F-4.

12. RELOCATIONS BY OTHERS

Additional relocations necessary in connection with the construction of the project, which can best be accomplished by the particular owners, include the following:

a. Removal by Boston and Maine Railroad of track and gasoline pump and vacating of premises on Boston side of the river.

b. Relocation by the Boston Edison Company of power cables crossing the river.

c. Relocation by the Metropolitan Boston Transit Authority of cables crossing the river.

d. Provision of a bypass roadway during a temporary closure of about three months of the Boston Sand and Gravel Co. right-of-way to Warren Avenue.

COST ESTIMATES

13. BASIS OF ESTIMATES

Estimates of quantities are based on completed plans prepared by consulting engineers for the MDC and quantity estimates as determined by them and reviewed by staff specialists of the New England Division. A three-year construction period was assumed for purposes of determining the Federal investment. Unit prices are based on average bid prices for similar work in the region, adjusted to the January 1968 price level.

The estimate includes an 11 percent allowance to cover contingencies rather than the customary 15 percent due to the detailed nature of the plans and specifications. The costs of engineering, design, supervision and administration have been based on knowledge of the site and experience on similar projects.

14. ANNUAL CHARGES

Annual charges are based on an annual interest rate of 3.25 percent and amortization over a 100-year economic life. An allowance is made for maintenance, operation, major replacements and for loss of productivity on lands transferred to Federal ownership. The major replacement allowance is for items deemed to have a usable life less than that of the project.

15. COST ESTIMATE

A breakdown of the major construction items together with their estimated cost is given in Table F-1.

16. COST ALLOCATION

The cost of the project has been allocated to the various project purposes by the "separable costs-remaining benefits" method. The allocation of annual charges and construction costs are given in Tables Nos. F-2 and F-3. Cost apportionment between Federal and Non-Federal are shown in Table F-4. Allocation by the "priority of use" method and the "incremental cost" method, for 50-year as well as 100-year project lives, are included as part of Attachment I.

TABLE F-1

ESTIMATED FIRST COST
(January 1968 Price Level)

WARREN AVENUE MULTI-PURPOSE DAM

CHARLES RIVER, BOSTON, MASSACHUSETTS

	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>LANDS & DAMAGES</u>				
Fee taking	4	acres	L. S.	\$ 150,000
Temporary easements	2	acres	L. S.	30,000
Improvements			L. S.	120,000
Severance damages				42,000
Acquisition costs				10,000
Contingencies				<u>48,000</u>
TOTAL LANDS & DAMAGES				\$ 400,000
<u>RELOCATIONS</u>				
2,000'-8' conduit	1	Job	L. S.	\$ 650,000
1,250'-7' subaqueous conduit	1	Job	L. S.	500,000
Relief sewers Charlestown for overflows to river	1	Job	L. S.	500,000
Enlarge BMC pumping station	1	Job	L. S.	800,000
Miscellaneous relocations by others	1	Job	L. S.	<u>250,000</u>
				\$2,700,000
Engineering & Design				330,000
Supervision & Administration				<u>270,000</u>
TOTAL RELOCATIONS				\$3,300,000

TABLE F-1 (continued)

	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>DAM & APPURTENANT STRUCTURES</u>				
Site Preparation & Cofferdam	1	Job	L. S.	3,707,600
Common Excavation-River Area	180,000	c. y.	3.00	540,000
Rock Excavation-River Area	200	c. y.	40.00	8,000
Common Excavation-Land Area	1,500	c. y.	2.50	3,750
Rock Excavation-Land Area	1,500	c. y.	20.00	30,000
Earth Excavation within Cofferdams	60,000	c. y.	2.50	150,000
Granular Refill	68,000	c. y.	2.50	170,000
Granular Fill	65,000	c. y.	3.00	195,000
Impervious Fill	6,000	c. y.	4.00	24,000
Bedding Stone-Furnish & Place	15,000	Ton	6.00	90,000
Temporary Bedding Stone	9,500	Ton	4.00	38,000
Protection Stone-750 Lb. Min.	1,000	s. y.	15.00	15,000
Protection Stone-2,000 Lb. Min.	3,000	s. y.	20.00	60,000
Riprap 18-inch Size	25,000	Ton	4.00	100,000
Riprap 24-inch Size	10,000	Ton	4.75	47,500
Temporary Stone Protection	15,000	Ton	5.50	82,500
Steel Bearing Piling- 10 BP 42	18,000	l. f.	6.50	117,000
Steel Bearing Piling - Coated	8,600	l. f.	10.00	86,000
Points for Piles	325	ea.	50.00	16,250
Steel Sheet Piling	12,200	s. f.	4.25	51,850
Steel Sheet Piling - Coated	23,400	s. f.	6.50	152,100
Timber Piling	26,000	l. f.	3.60	93,600
Steel Bearing Test Piles	250	l. f.	8.00	2,000
Steel Bearing Test Piles-Coated	250	l. f.	12.00	3,000
Timber Test Piles	300	l. f.	7.00	2,100
Pile Load Test - Steel Bearing Pile	3	ea.	7,000.00	21,000
Pile Load Test - Timber Pile	3	ea.	4,500.00	13,500
Settlement Platforms	12	ea.	60.00	720
Roadway, Parking Area and Landscaping	1	job	L. S.	103,000
36" R. C. Pipe(Combined sewer)	400	l. f.	25.00	10,000
Water Stops	34,000	l. f.	3.00	102,000
Water, sewer & Drainage	1	job	L. S.	87,100
Reinforced Concrete	84,000	c. y.	56.50	4,746,000

TABLE F-1 (continued)

<u>Description</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
Precast Concrete Roof Plank	1	job	L. S.	18,000
Precast Arch. Conc. Wall Panels	1	job	L. S.	125,000
Concrete Masonry Units	1	job	L. S.	6,500
Glazed Struct. Tile Units	1	job	L. S.	6,000
Structural Steel	1	job	L. S.	421,000
Trash Racks, Lifting Beams and Bulkheads	1	job	L. S.	180,000
Misc. Ferrous Metals	336,000	lbs.	0.85	285,600
Misc. Non-Ferrous Metals	59,200	lbs.	3.50	207,200
Aluminum Stairs	1	job	L. S.	18,000
Steel Stairs	1	job	L. S.	15,000
Misc. Work - Viaduct	1	job	L. S.	53,000
Carpentry & Millwork	1	job	L. S.	6,000
Roofing, Insulating & Flashing	1	job	L. S.	10,000
Waterproofing & Caulking	1	job	L. S.	2,500
Metal Door & Frames	1	job	L. S.	3,500
Aluminum Windows & Walls	1	job	L. S.	250,000
Gloss and Glazing	1	job	L. S.	65,000
Terrazzo Flooring	1	job	L. S.	1,800
Quarry Tile	1	job	L. S.	25,000
Acoustic Ceilings	1	job	L. S.	1,000
Metal Lath and Plaster	1	job	L. S.	1,000
Painting	1	job	L. S.	50,000
Concrete Coating	1	job	L. S.	10,000
Access Floor	1	job	L. S.	7,000
Toilet Partitions	1	job	L. S.	330
Finish Hardware	1	job	L. S.	3,000
Lock Gates & Equip.	1	job	L. S.	1,830,000
Navigation Aids	1	job	L. S.	335,000
Material Handling Equip.	1	job	L. S.	35,000
Instrumentation	1	job	L. S.	55,000
Plumbing	1	job	L. S.	65,000
Heat. Vent. & Air Conditioning	1	job	L. S.	140,000
Electrical Work	1	job	L. S.	450,000
Pumping Station Equip. - Installation & Testing	1	job	L. S.	300,000
Pumps (1,400 cfs capacity)	6	ea.	L. S.	2,650,000
			\$	18,500,000
Contingencies				2,000,000
			\$	20,500,000
Engineering and Design				800,000
Supervision and Administration				1,500,000
TOTAL DAM & APPURTENANT STRUCTURES			\$	22,800,000
TOTAL PROJECT FIRST COST			\$	26,500,000

TABLE F-2

WARREN AVE. MULTI-PURPOSE DAM
SUMMARY OF COST AND ANNUAL CHARGES
(In \$1,000 at 1968 Price Level)

Permanent Features	MULTI-PURPOSE PROJECT				ALTERNATIVE DUAL PURPOSE				ALTERNATIVE SINGLE PURPOSE	
	F. C.	Specific Cost	H/W Trans.	Dual Joint Use Cost	Total Cost	Nav. & H/W Trans.	F. C. & H/W Trans.	F. C. & Nav.	F. C.	H/W Trans.
Lands and Damages										
Relocations										
Structures	7,600	3,000	900	3,200(2)	400 3,300 22,800	350 3,300 15,250	400 3,300 20,400	400 3,300 21,800	400 3,300 19,400	300 100 1,300
TOTAL PROJECT FIRST COST	7,600	3,000	900	3,200	26,500	18,900	24,100	25,500	23,100	1,700
Investment										
Interest During Construction	350	150	50	150	1,300	900	1,150	1,250	1,150	100
TOTAL	7,950	3,150	950	3,350	27,800	19,800	25,250	26,750	24,250	1,800
Annual Charges										
Interest	258	103	31	109	403	643	821	869	788	58
Amortization	11	4	1	5	17	27	35	37	33	2
Operation & Maintenance (1)	35	88	2	9	34	145	80	165	77	5
Major Replacement	7	9			16	10	10	16	10	
Loss of Productivity of Land				1	4	4	5	5	5	3
TOTAL ANNUAL CHARGES	311	204	34	124	458	829	951	1,092	913	68

(1) Flood control portion based on 100 year economic life, Nav/Trans portions based on 50 year economic life converted to 100 year series.

(2) Specific cost to flood control and navigation \$3,200,000 sewer extension.

TABLE NO. F-3

COST ALLOCATIONS
(In \$1,000 at 1968 Price Level)

	<u>Flood Control</u>	<u>Navi- gation</u>	<u>Highway trans- portation</u>	<u>Total</u>
<u>ALLOCATION OF ANNUAL COST</u>				
Benefits	1660 (1)	397 (2)	68	2,125
Alternate cost	913	788	68	--
Benefits limited by alternate cost	913	397	68	1,378
Separable cost	302	180	39	521
Remaining benefits	611	217	29	857
Ratio of remaining benefits (3) - % (Dual Separable)	73.79	26.21	0	100.00
Remaining Benefits (Dual Separable)	92	32	0	124
Remaining Benefits	519	185	29	733
Ratio of Remaining Benefits - %	70.80	25.24	3.96	100.00
Allocated joint cost	432	154	24	610
Total allocation, project cost	734	334	63	1,131
<u>ALLOCATION OF OPERATION & MAINTENANCE COSTS</u>				
Separable cost	23	88	3	114
Allocated joint cost	38.3	13.6	2.1	54
Total allocation O&M	61.3	101.6	5.1	168
Specific costs	35	88	2	125
Allocated joint use costs	26.3	13.6	3.1	43
Ratio for allocation of joint use O&M	61.16	31.63	7.21	100.00
<u>ALLOCATION OF MAJOR REPLACEMENTS</u>				
Separable cost	6	6	0	12
Allocated joint cost	2.8	1.0	0.2	4
Total allocation, major replacements	8.8	7.0	0.2	16
<u>ALLOCATION OF NET LOSS OF PRODUCTIVITY</u>				
Separable cost	1	0	0	1
Allocated joint cost	2.8	1.0	0.2	4
Total allocation, net loss of productivity	3.8	1.0	0.2	5
<u>ALLOCATION OF INVESTMENT</u>				
Annual investment cost	660.1	224.4	57.5	942
Ratio of annual investment %	70.08	23.82	6.10	100.00
Allocated investment	19,480	6,623	1,697	27,800
<u>ALLOCATION OF CONSTRUCTION EXPENDITURES</u>				
Specific investment	7,950	3,150	950	12,050
Investment in joint use facilities	11,530	3,473	747	15,750
Construction expenditures in joint use facilities	10,990	3,300	710	15,000
Percent of construction expenditures in joint use facilities	73.2	22.1	4.7	100.00
Construction expenditures in specific facilities	7,600	3,000	900	11,500
Total construction expenditures	18,590	6,300	1,610	26,500
<u>SUMMARY</u>				
Total construction expenditures	18,590	6,300	1,610	26,500
Annual costs	734	334	63	1,131
Annual benefits	1,660	397	68	2,125
Benefit/cost ratio	2.3	1.2	1.1	1.9

(1) Includes \$138,000 of advanced replacement at existing Charles River Dam allocated to Flood Control.

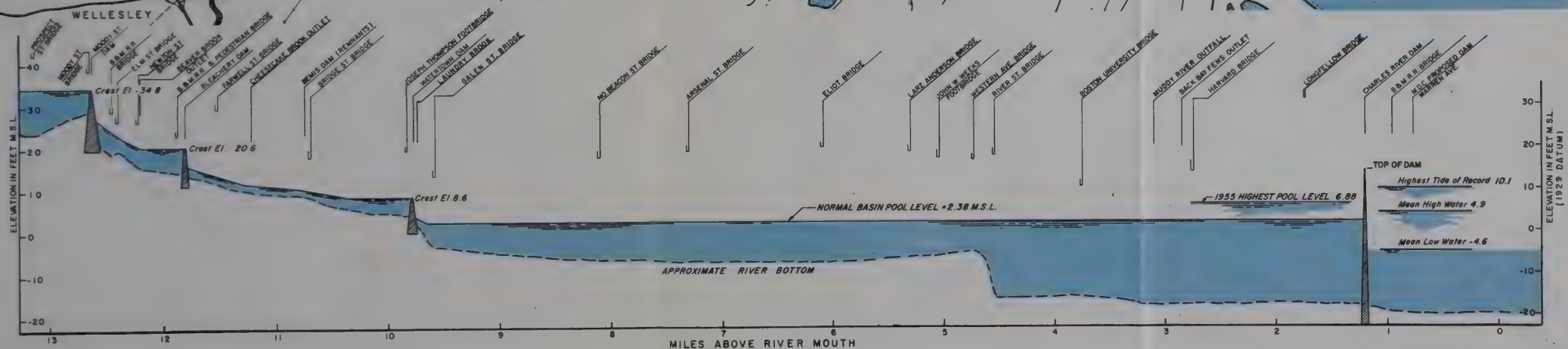
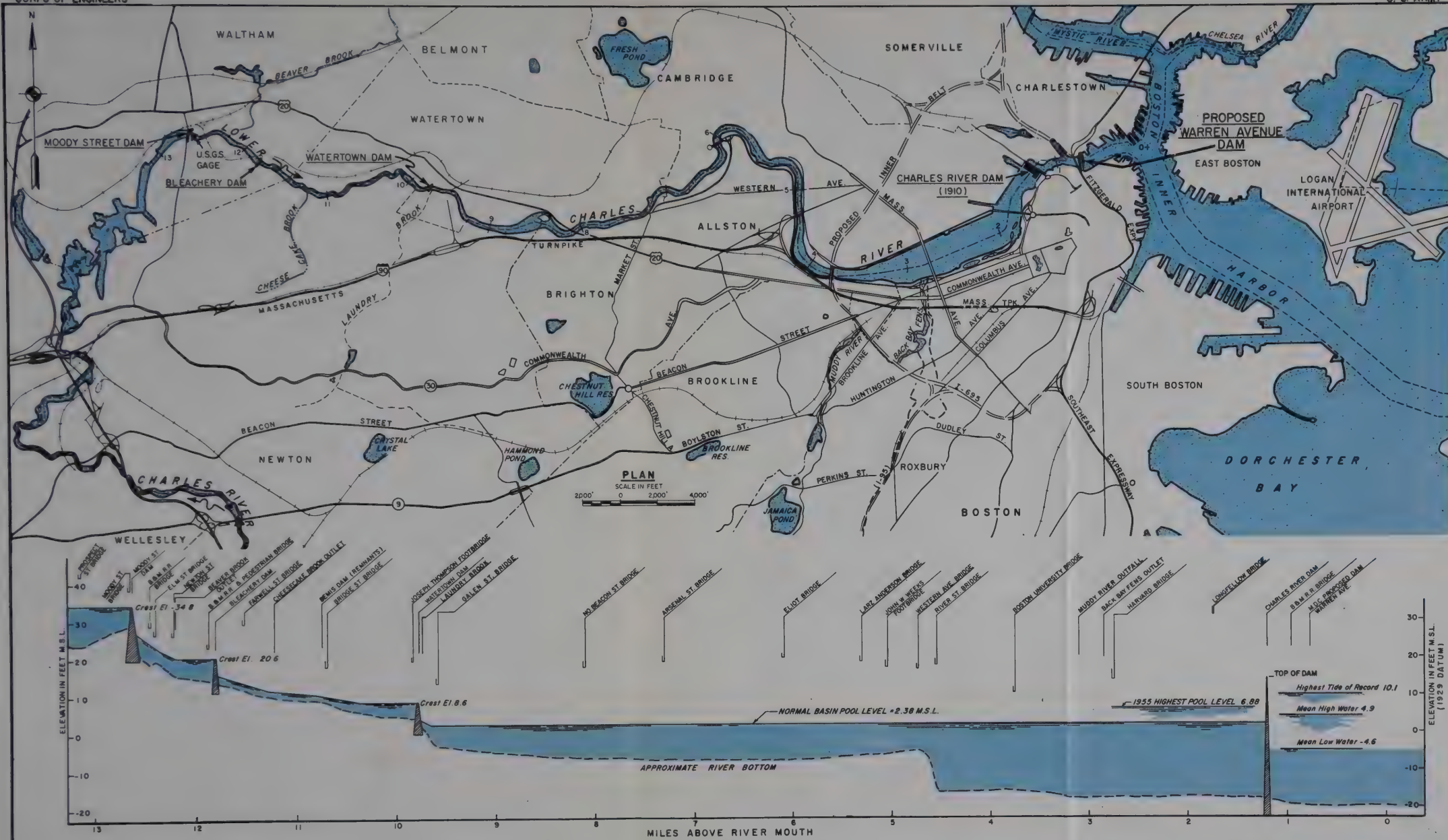
(2) Includes \$68,000 of advanced replacement at existing Charles River Dam allocated to Navigation.

(3) Specific cost to flood control and navigation \$3,200,000 sewer extension.

TABLE F-4

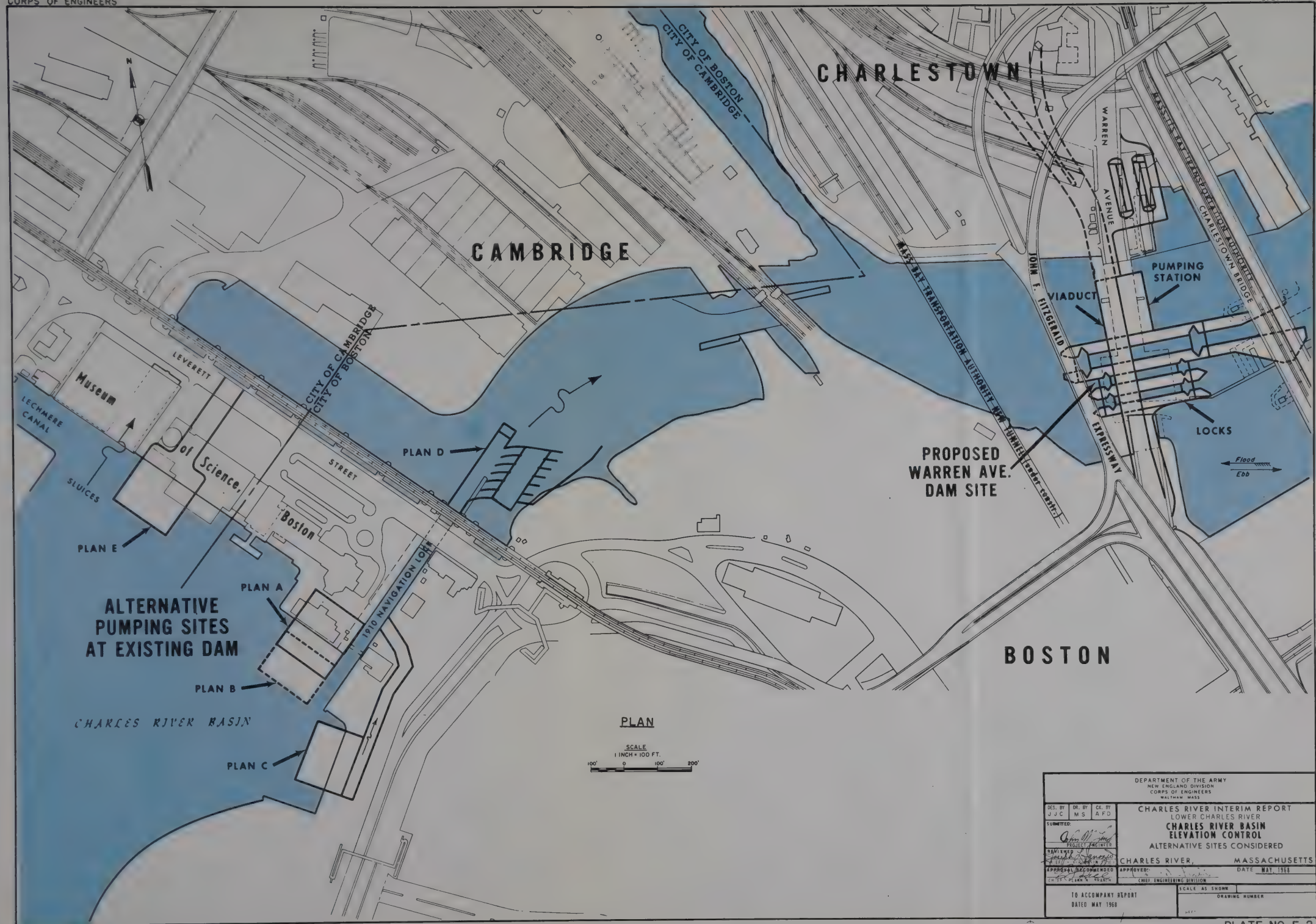
COST APPORTIONMENT
(in \$1,000 at 1968 Price Level)

	<u>Federal.</u>	<u>Non-Federal</u>	<u>Total</u>
<u>Flood Control</u>			
Lands and Damages	0	300	300
Relocations	0	2,420	2,420
Structures	15,870	0	15,870
Total	15,870	2,720	18,590
<u>Navigation</u>			
Lands and Damages	0	80	80
Relocations	0	720	720
Structures	2,750	2,750	5,500
Total	2,750	3,550	6,300
<u>Highway Transportation</u>			
Lands and Damages	0	20	20
Relocations	0	160	160
Structures	0	1,430	1,430
Total	0	1,610	1,610
TOTALS	18,620	7,880	26,500
<u>Summary</u>			
Lands and Damages	0	400	400
Relocations	0	3,300	3,300
Structures	18,620	4,180	22,800
Percent of Structures	81.7	18.3	100

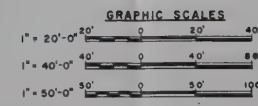
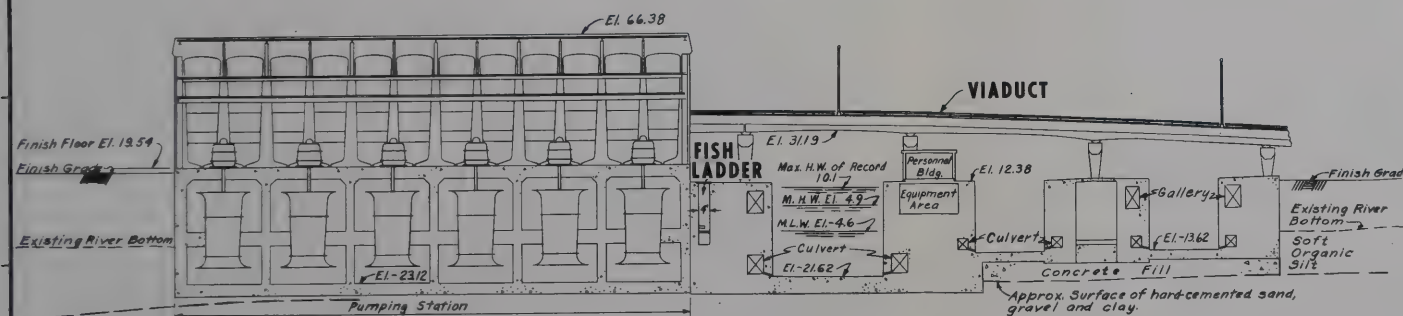
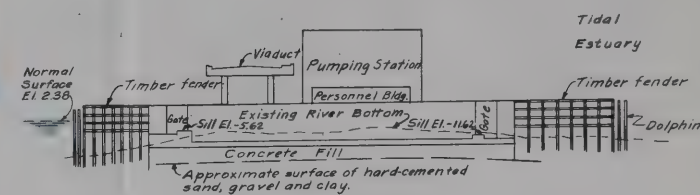
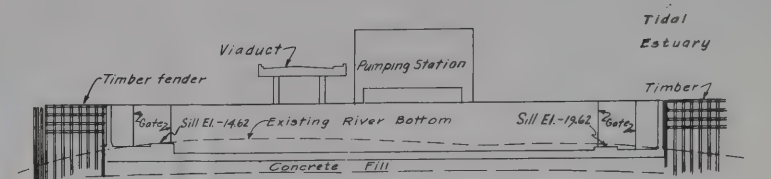
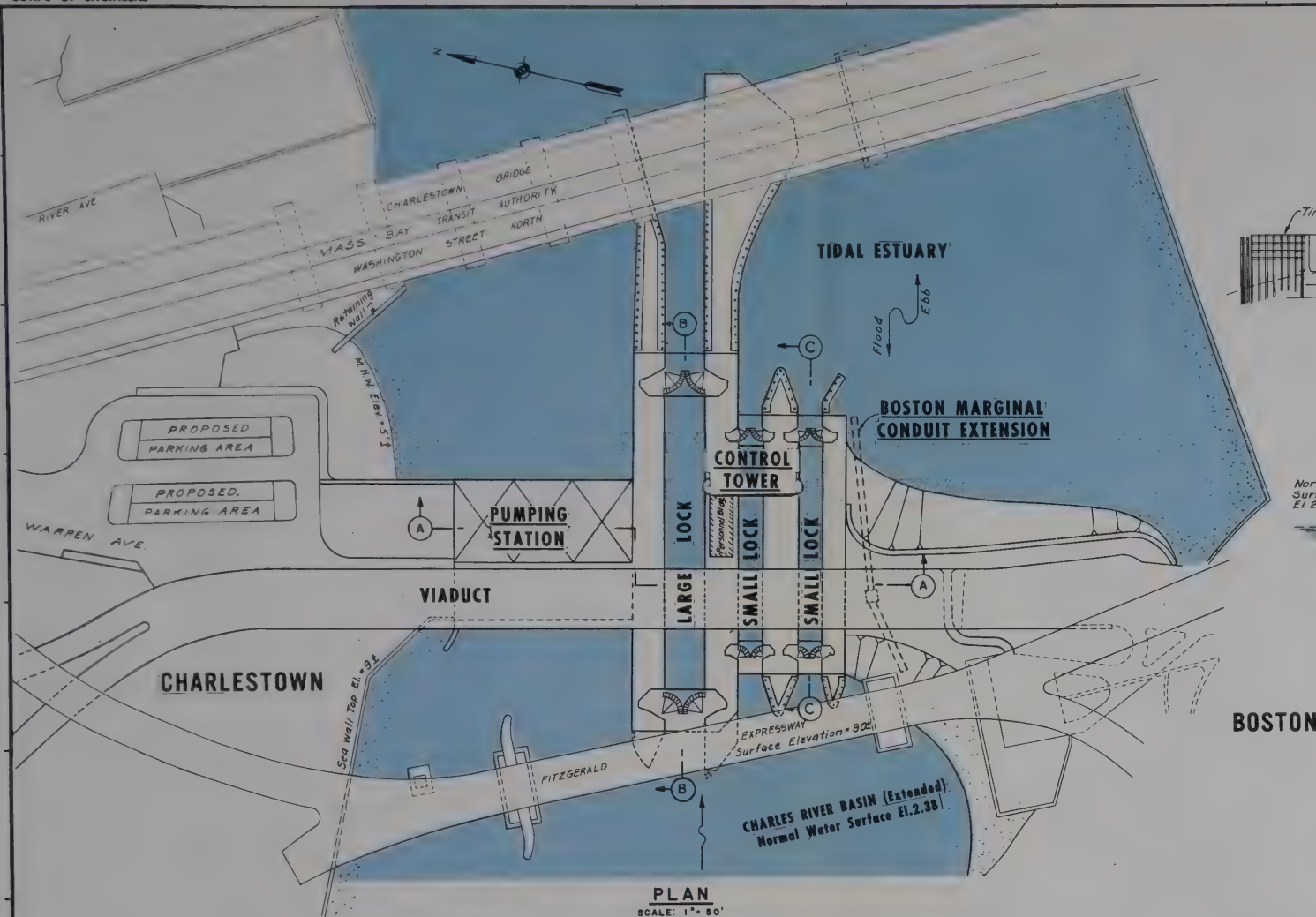


PROFILE
HOR. SCALE: 1" = 2,000'
VERT. SCALE: 1" = 10'

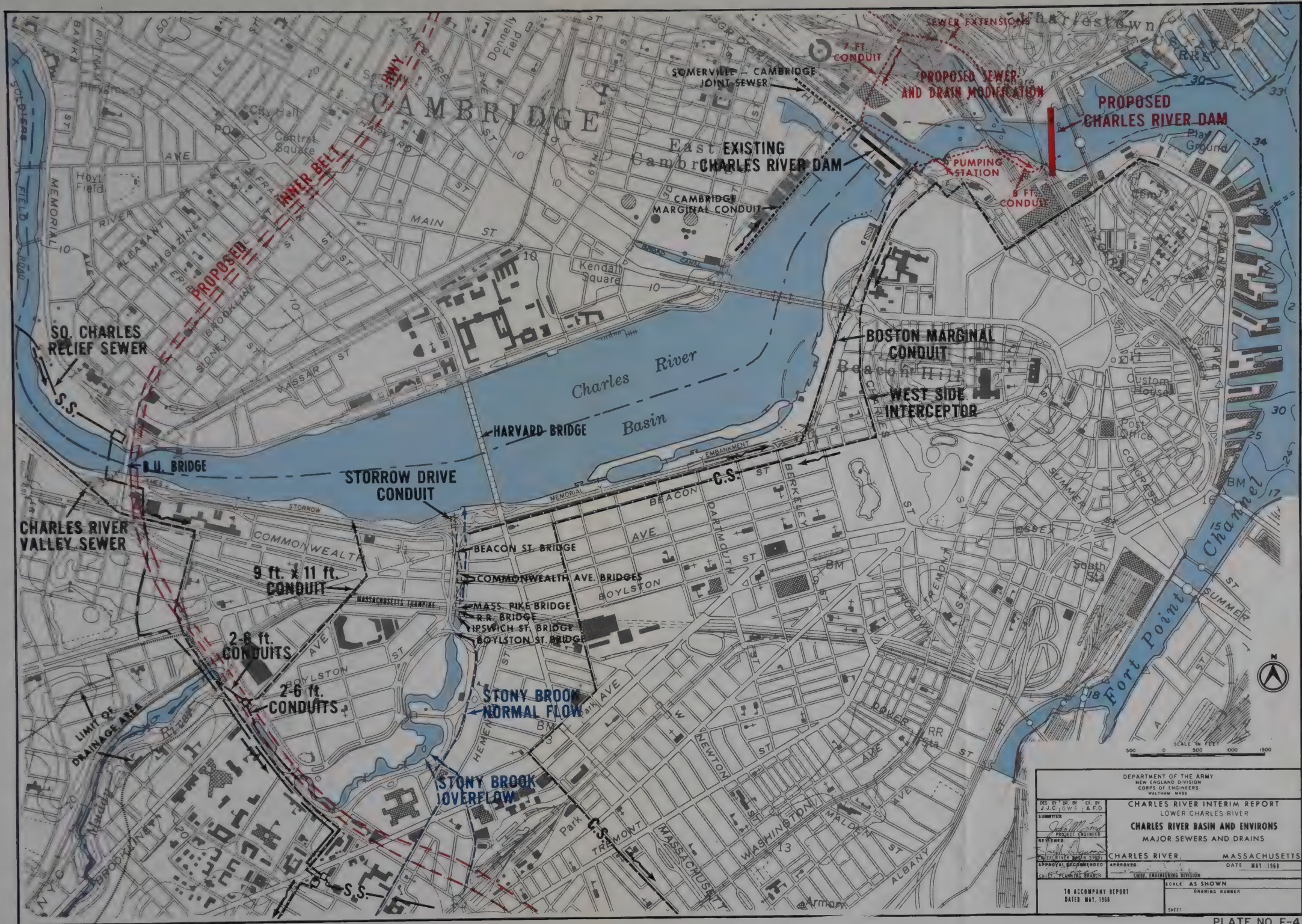
DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.			
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER			
PLAN AND PROFILE			
DES. BY: J.C. CHANDLER SUBMITTED: [Signature] REVIEWED: [Signature] APPROVED: [Signature]		CHARLES RIVER, MASSACHUSETTS DATE: MAY 1960	
TO ACCOMPANY REPORT DATED: MAY, 1960		SCALE: AS SHOWN DRAWING NUMBER SHEET	



DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.			
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER CHARLES RIVER BASIN ELEVATION CONTROL ALTERNATIVE SITES CONSIDERED			
DES. BY JJC	DR. BY MS	CL. BY AFD	DATE MAY 1968
SUBMITTED <i>[Signature]</i> PROJECT ENGINEER			APPROVED <i>[Signature]</i> CHIEF ENGINEERING DIVISION
TO ACCOMPANY REPORT DATED MAY 1968			SCALE AS SHOWN DRAWING NUMBER



DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.	
CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER ELEVATION CONTROL PROPOSED CHARLES RIVER DAM PLAN AND SECTIONS	
DES. BY J.J.C. M.W.B. I.A.F.D. SUBMITTED: [Signature] REVIEWED: [Signature] APPROVED: [Signature] CHIEF, CIVIL ENGINEERING DIVISION	CHARLES RIVER, MASSACHUSETTS DATE MAY, 1960 SCALE: AS SHOWN DRAWING NUMBER SHEET
TO ACCOMPANY REPORT DATED MAY, 1960	



DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.		CHARLES RIVER INTERIM REPORT LOWER CHARLES RIVER CHARLES RIVER BASIN AND ENVIRONS MAJOR SEWERS AND DRAINS CHARLES RIVER, MASSACHUSETTS	
DESIGNED BY J.W.C. G.V.S. J.A.F.D.	PROJECT ENGINEER [Signature]	APPROVED [Signature]	DATE MAY 1960
TO ACCOMPANY REPORT DATED MAY 1960		DRAWING NUMBER SHEET	

APPENDIX G

ECONOMICS

APPENDIX G

ECONOMICS

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APPENDIX G

ECONOMICS

PLATES

<u>Title</u>	<u>Plate</u>
Damage Frequency Curve, Muddy River	G-1
Stage Damage Curve, Muddy River	G-2
Flood Area	G-3

APPENDIX G

ECONOMICS

1. GENERAL. The Boston SMSA is the sixth largest in the country. The five communities clustered around the lower Basin - Boston, Brookline, Cambridge, Newton and Watertown - lie at the very center of the SMSA and comprise the commercial, industrial, educational and cultural heart of the entire region.

The economy of the urban communities is solidly based on a varied mix of industry, commerce, education, Government and research and development.

PRESENT CONDITIONS

2. BOSTON

a. General. Boston, the state capital and the most populous city in New England, is the Government and financial center of the New England Region. Its roots deep in the country's history, the city is today a blend of the past and the present with modern office buildings and stores shouldering historic shrines like the Old State House and Old North Church.

b. Communications. Boston is the commercial and distribution center of New England. It is a major national and international air terminal, the regional hub for New England's rail, truck and bus services and its leading port. Traffic in the area is serviced by an integrated rail, highway and air transportation system.

The Massachusetts Bay Transportation Authority operates a combination of rapid transit lines, surface street car lines and feeder bus routes to serve Boston and connect it to its suburbs.

c. Education. A leader in the educational field, Boston is the site of two major universities, Boston University and Northeastern University. The Medical School and the Business Administration School of Harvard University are located here as is the Medical School of Tufts University. Smaller colleges in the city include Simmons, Emmanuel, Emerson and the New England Conservatory of Music. Numerous specialty schools - business, art, accounting and the like - are also to be found here as well as several junior colleges and teachers colleges.

d. Economy. While Boston is only secondarily a manufacturing center, its product has a value added in excess of \$700,000,000 annually and employs over 70,000 people. Boston's primary function in the region of which it is the center is in trade and finance. Wholesale and retail trade is the largest employer in the city with an estimated 120,000 employees. Finance, insurance and real estate are an important segment in the city's economy with an estimated employment of 57,000 people. Annual sales in Boston retail establishments exceed one billion dollars.

Tourism, especially in the summer months, is an important factor in the economy. With a wealth of nationally famous shrines connected with early history - Bunker Hill Monument, The Old North Church, Faneuil Hall and the U. S. S. Constitution to name but a few - the city is a Mecca for tourists from throughout the country.

f. Land Use. With the exception of its park lands, the entire city is almost completely built over. Urban renewal, both public and private, is now going on in the center of the city. The public renewal program is being carried out with Federal Urban Renewal Funds (over \$150 million to date). The private renewal program represents individual investments by major banks and insurance companies.

3. CAMBRIDGE

a. General. Cambridge is two communities; an academic community housing two of the nation's major educational institutions, Harvard and Massachusetts Institute of Technology, existing side by side with one of the most heavily industrialized cities in Massachusetts. With only 7.4 square miles of land, the city is densely built over except for the college campuses.

b. Education. Imposing in their physical plant, Harvard and M.I.T. occupy sizeable portions of the city's limited land area. Heavily endowed (Harvard's endowment exceeds \$1 billion and is the country's largest; M.I.T.'s endowment is the largest of any engineering school) the schools have developed aesthetically pleasing campuses, Harvard's in the very heart of the city and extending to the Charles, M.I.T.'s lying along the Charles in the city's eastern section.

The institutions are each pre-eminent in their own field. Their graduate schools of law, engineering, physical sciences, and public administration are world famous. Government and industry bring their more complex problems to these schools for solutions and their research programs are enormous. Around these programs a satellite group of private research and development facilities has grown up and these are

generating an increased demand for space in the city. The availability of these institutional and private research facilities was a factor in the establishment of the National Aeronautic and Space Administration Research Center in Cambridge.

c. Economy. Lying generally to the east of the academic community is the city's industrial plant. Housed in mainly aging facilities are manufacturers of a wide variety of products ranging from candy to electronic components and from cameras to rubber belts for industry. While much of the product is regionally oriented as to market, producers for the national market are also located in the area. It is estimated that over 27,000 people are employed in manufacturing in Cambridge in more than 250 separate establishments with an annual product in excess of \$500 million.

d. Land Use. As previously noted, land is in critically short supply in Cambridge. With the exception of some land along its western boundary, the city is completely built over or reserved in the college campuses. A start has been made on urban renewal but as yet the effect is small.

4. THE BEDROOM COMMUNITIES

a. General. The three communities lying to the west of Boston and Cambridge in the lower basin were in an earlier period mainly bedroom suburbs for Boston and Cambridge.

b. Brookline. With the exception of a small portion of its western boundary, Brookline is completely surrounded by Boston. With the Massachusetts Bay Transportation Authority serving the bulk of the community and giving fast access to downtown Boston, the town is, as in an earlier period, a bedroom suburb.

There is little industry in the town and its commercial development is limited to that necessary to serve the local market. The eastern portion of the town is completely built over except for a narrow strip of park land edging Muddy River. While its western portion is not as densely settled, two golf courses and a large estate left to the town as a museum combined with less suitable topography for development preclude much expansion of housing in the area beyond that which already exists.

c. Newton. A small portion of the City of Newton abuts the lower Charles River Basin. Only a parkway along the river bank and some recreational facilities occupy the flood plain and, as the entire flood plain is on Metropolitan District Commission land, no other development can be expected in this area.

The city itself, which is in the upper Charles River Basin, is unlike any of the other communities in the lower basin. Originally, Newton was made up of eleven villages scattered along two commuter lines of the Boston and Albany Railroad. Service on the lines was frequent and the villages grew, primarily as bedroom communities for the more affluent of Boston's work force. What industry the city had was located on its southern border and along the Charles River. Commerce in the city was limited to the essential trade facilities to be expected in any village at each of the village centers.

From the 1920's on, the city had a rapid expansion in population. While still largely a bedroom suburb of Boston, the manufacturing industry is becoming an important feature in the city's economy. Wholesale and retail trade have also grown, especially since 1950. The city's land is well built over and an urban renewal program is presently under consideration.

d. Watertown. Watertown differs from the other communities in the lower Charles River basin in the manner it has developed in the past. Slightly more isolated than the other communities so far as transportation was concerned the town developed in the manner of inland New England communities; an industrial base furnishing the underpinning of a stable, slow growing economy less related to the region than in the other communities of the basin. A major factor in the economy for years was the U. S. Army's Watertown Arsenal, now closed, but the private industrial sector was an important one also. The town, which has the option of taking over the Arsenal at GSA's price, is considering several development alternatives for the property but as yet has finalized no plans. In the recent past, the manufacture of controls and other electronic components has been an increasingly important portion of the manufacturing segment of the economy as the demand generated by research and development in nearby Cambridge makes an expanding market for such products. With surface transportation to Cambridge on three separate bus lines of the MBTA, the town has become a bedroom suburb for the overflow from the academic community of that city. The town is almost completely built over but the relatively narrow flood plain is lightly developed.

FUTURE CONDITIONS

5. GENERAL. The economic region of which the Boston SMSA is the center has been projected to have population growth of 23.2% by 1980 and 69.5% by the year 2000. By 2020 the population will more than double. In 1980 the urban population of the region is expected to be 91.3% of the total, while in the year 2000 the percentage will be 93.9%.* As the region at the present time has approximately four times the population of the lower basin communities, it is not necessary to break the regional data down to know that the demand for space in these communities will be critical.

*Data from the report of Arthur D. Little, Inc. entitled "Projective Economic Studies of New England", Part III, Sub-State Areas, Table 4.

6. BOSTON. While Boston is declining as a population center and will probably show some further decline in the near future, its population should stabilize by 1980 at a figure of about 550,000. Even this figure represents a density of over 12,000 people per square mile, so the demand for housing space will continue to be high. The expansion in trade, finance, education, services and government necessary to meet the demands created by the projected growth for the region will put a further strain on building space in the city.

To meet this demand for building space in an area which is already built over a combination of urban renewal and an upgrading of present facilities will take place. (As used here urban renewal presumes removing and replacing of existing facilities).

For the properties in the flood plain, both means will be resorted to. The result will be to add to the value of property subject to flooding and to increase the loss potential in the flood plain over time.

7. CAMBRIDGE. Like Boston, Cambridge has had a decline as a population center although percentage-wise the drop has been much less severe. Unlike Boston's loss which mainly represented the country-wide trend of flight from the urban centers to the suburbs, much of the Cambridge loss represented displacement as the academic community expanded. Further expansion is planned.

As previously noted, there is a growing demand for space for research and development projects in the private sector of the economy. The over-riding consideration for the projects is nearness to and access to the laboratories, computers and staff of the Graduate Schools of Harvard and M.I.T. The initial space requirements are often small and in the past have been met by older homes, basement space in industrial plants and in un-used stores. With time, these concerns expand, space requirements grow, and larger quarters are sought. The establishment of NASA's Electronics Research Center in Cambridge is going to add to the demand of space.

The combined effects of university expansion, manufacturing space requirements and the demands of research and development will be to put a premium on every square foot of building space in Cambridge. As in Boston, the result will be an increase in property values and in future loss potential in the flood plain.

8. THE BEDROOM COMMUNITIES. In Brookline, Newton and Watertown present land use or ownership precludes any substantial increase in the loss potential of the flood plain in the foreseeable future.

FLOOD LOSSES AND BENEFITS

9. **DAMAGE SURVEYS.** Following the flood of August 1955, the Metropolitan District Commission engaged two private engineering firms to make a survey of the flood losses along the Charles River and its tributaries in the Greater Boston area. The survey consisted of a limited sampling of physical losses only. In late 1967 and early 1968, Corps of Engineers personnel made a damage survey of the lower end of the Charles River Basin between Embankment Road, Boston and Cambridge, and Galen Street Bridge, Watertown. Data from the earlier survey were used to aid in evaluating flood depths and limits but a complete evaluation of losses was made in the light of current conditions. The survey consisted of door to door interviews and inspections of residential, commercial, industrial and other properties within the flood plain. Recorded information included extent of the areas flooded, description of the properties, nature and amount of damages, depth of flooding, high water references and relationships to prior flood stages. Damage data were generally furnished by property owners or tenants. Engineers and analysts prepared estimates on the basis of these data and developed their own estimates when owner or tenant estimates were unavailable.

Sufficient data were obtained to derive losses for (1) the 1955 flood crest, (2) stages two and three feet higher, (3) the stage where damage begins, referenced to the 1955 flood crest, and (4) intermediate stages where marked increases in damage occur.

10. **LOSS CLASSIFICATION.** Flood loss information was recorded by type of loss and by location. Primary losses evaluated include (1) physical losses, such as damage to structures, equipment and machinery, and raw and finished stock, and costs of cleanup and repairs, and (2) nonphysical losses, such as unrecoverable loss of business and wages, cost of emergency services, costs of traffic congestion and detouring and other increased costs of operation.

Primary losses resulting from physical damage and a large part of the related nonphysical loss were determined by direct inspection of property and evaluation of losses by property owners and field investigators. Where nonphysical portions of primary losses could not be directly determined with available data, estimates were based upon the relationship between physical and nonphysical losses for similar properties in the area.

11. **RECURRING LOSSES.** A recurrence of the record flood levels of August 1955 under 1968 conditions would cause losses estimated at \$12.4 million in the Greater Boston portion of the Charles River Basin. By communities the losses would break down percentage-wise as follows: Boston, 35.3%, Cambridge, 64.3%, Brookline, 0.3%, and Watertown, 0.1%.

By types, the losses have the following breakdown:

<u>Type of Loss</u>	<u>Amount</u>
Urban (Commercial, Residential Public)	\$3.9 million
Industrial	3.2 million
Institutional	\$4.1 million
Transportation (highway)	<u>\$1.2 million</u>
Total:	\$12.4 million

12. TRENDS OF DEVELOPMENT. Based on data on direct losses contained in the report on flood losses prepared by engineers engaged by the Metropolitan District Commission and information on nonphysical losses obtained by Corps' damage analysts in the 1967-1968 survey of flood losses, it is estimated that the experienced loss in 1955 was \$5.5 million. The 1968 recurring losses amount to \$11.1 million. Discounting for the depreciation in dollar value since 1955 this represents a 78.6% increase in losses in the 13-year period. The increase was brought about by expansion of facilities in the flood plain and by more intensive use in some existing facilities.

As noted previously, the region of which the lower Basin communities form the economic core is projected to grow in population at an increasing rate, more than doubling by 2020. It was also noted that this increase in population would generate pressure for additional construction in the region's center to meet the need for additional space to provide the expanded services and government facilities made necessary by the projected growth.

It was further noted that both the academic institutions in Cambridge are committed to additional expansion and additional demands for space are being made by research and development firms.

To reflect this expected growth in facilities (and loss potential) recurring losses were adjusted for conditions projected to occur in 2000 and 2020. It was assumed that the entire loss potential would be attained by 2020.

13. ANNUAL LOSSES. Estimated recurring loss data at various stages of flooding were combined with stage - frequency data for river stages to derive damage-frequency relationships as a measure of annual losses under present and projected conditions. Generally, there is a ten year lapse in time between a submission of a favorable report and completion of a recommended project. The current policy of budgetary stringency

might have some effect on the time period but for this report it is assumed that the base year for a new dam coming into operation would be 1978. Discounting for the change in dollar value since 1955 there has been an increase of 78.6% in recurring losses since 1955 or an annual increase of 5.6%. The loss potential is projected to grow at a third of the historic rate over the next 10-year period. The continuing urbanization of the area upstream of the lower basin, combined with changes in the pattern of storm drainage systems as new regional highways are constructed, will mean that a given flood event will be more frequent after 10 years. The derivation of the basic annual loss was therefor based on loss potential and stage - frequency to be expected 10 years hence. Annual losses so derived amount to \$1,020,000 consisting of \$837,000 on the Charles River and \$183,000 on the portion of Muddy River affected by the Charles River pool level. The stage - loss data were also combined with stage-frequency data for harbor stages to determine damage frequency for tidal flooding, if the embankment dam were not in existence. Plates G-1 and G-2 show derivation of annual losses for one reach of the studied area. For the years 2000 and 2020 there will be even greater changes in the flood frequency pattern. As noted in Trends of Development, paragraph 12, the pressures generated by the population growth of the region of which Greater Boston is the core will demand the highest usage of every square foot of flood plain property. Recurring losses for the periods were therefor adjusted at a rate which is two-thirds of the projected population growth for the periods. The adjustment is considered conservative in the light of past and current loss trends in New England. The projected losses were discounted to an average annual equivalent basis using an interest rate of 3½%. The average annual equivalent value of the future losses amounts to \$665,000. Total average annual equivalent loss amounts to \$1,685,000.

14. TANGIBLE FLOOD CONTROL BENEFITS. Tangible average annual flood control benefits were derived as the difference between annual losses expected in the Lower Charles River Basin over time with the existing dam but without the project and those that would remain after construction of a new dam with proposed new lock and pumping station to improve control of basin water levels. Benefits so derived amount to \$1,282,000 on an average annual equivalent basis. Of the total benefits, \$750,000 are to present development and \$532,000 is the average annual equivalent value due to future growth and more frequent flooding.

15. HIGHER UTILIZATION. In the course of the field survey of damages it was determined that over 800,000 square feet of basement space in commercial and industrial properties formerly used for storage or other operations is currently under-utilized because of the threat of flooding made evident by the 1955 flood. Holding the basin level to nondamaging levels will permit higher usage of this floor space. Current rental values for warehousing and storage space in Eastern Massachusetts run from

\$0.25 to \$1.00 per square foot depending on utilities furnished and accessibility for trucking. Considering all factors involved in the basement space in these plants it is reasonable to assign an annual value of \$0.30 per square foot to increased utilization. The total benefit from higher utilization of space amounts to \$240,000 annually. Adding this to the tangible flood control benefits, the total average annual flood damage prevention benefits amount to \$1,452,000.

16. ADVANCED REPLACEMENT BENEFIT. As previously noted, the present dam acts as a barrier to prevent tidal flooding in the basin upstream of the dam. With high tidal stages in Boston Harbor, a frequent occurrence, the benefits to the prevention of tidal flood damage in the area above the dam exceed \$33 million annually. Assuming that the existing dam has a life expectancy of 42 years, to the year 2010, and that a new dam can be constructed at Warren Avenue, downstream of the present structure, by 1978, will extend the useful life of the present dam as a tidal barrier until 2078. The new dam can be credited with advance replacement benefits for the period 2010 to 2078. While in theory the present annual benefit for the prevention of tidal flooding is the measure of the benefit, the analysis was based only on the cost of the construction and replacements necessary to make the present dam functionally operable in 2010, or \$10 million. The computation of the benefit is set forth below:

a. Unneeded cost of replacement benefit:

(1) Annual cost, \$10 million construction, $3\frac{1}{4}\%$ interest, 100 years = \$339,000.

(2) Compound P.W. factor for 68 years @ $3\frac{1}{4}\%$ = 27.273060

(3) Single payment P.W. factor for 32 years @ $3\frac{1}{4}\%$ = 0.359350

(4) $\$339,000 \times 27.273060 \times 0.359350 \times 0.033883 = \$112,573$, called \$113,000.

b. Unneeded operation and maintenance benefit:

(1) Annual cost = \$140,000

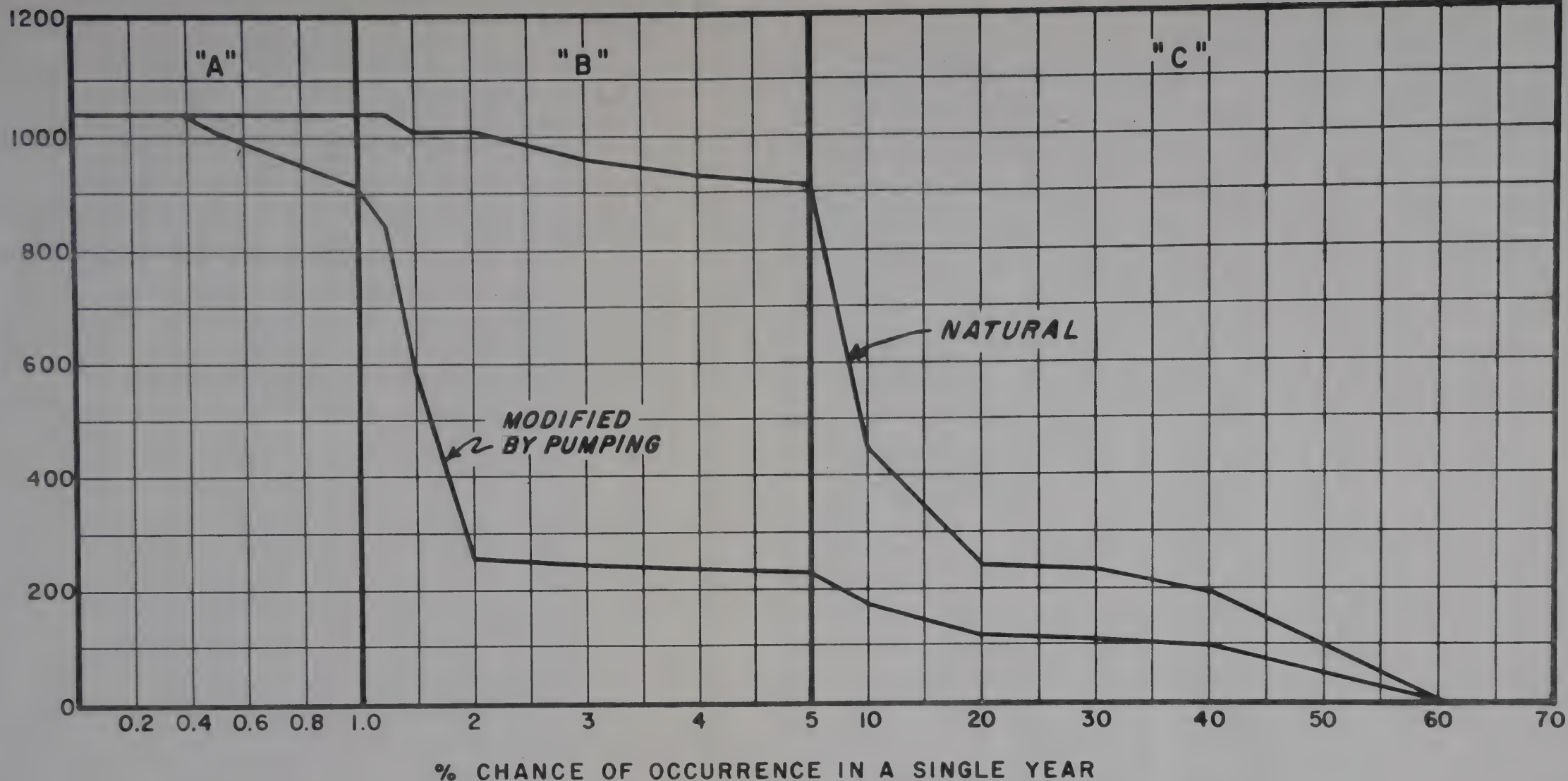
(2) Compound P.W. factor for 32 years @ $3\frac{1}{4}\%$ = 19.712296

(3) $\$140,000 \times 19.712296 \times 0.033883 = \$93,508$, called \$93,000

c. Total annual advance replacement benefit = \$113,000 + 93,000 = \$206,000 which is a project benefit.

17. UNEVALUATED TANGIBLE BENEFITS - AREA REDEVELOPMENT BENEFITS. In areas which have been designated Redevelopment Areas by the Economic Development Administration, under I. L. 89-136, it is permissible to claim as a benefit to a project the wages paid to workers on the project who in its absence would be otherwise unemployed or underemployed. The basic requirement for designation as a Redevelopment Area is an unemployment rate substantially higher than the National average. While the Boston Labor Market Area as a whole has an unemployment rate just below the National average, both Boston and Cambridge have minority groups with unemployment rates several times the National average. The Roxbury-North Dorchester section of Boston is a sizeable community in its own right with over 90,000 residents. In a special study by the Bureau of Labor Statistics in 1966-1967 this area was found to have an unemployment rate of 7% compared with the Boston Labor Market rate of 3.3%. It was further found that the slum area of this portion of the city had an unemployment rate of 24.2%. Independent communities much smaller than the study area have been designated Redevelopment Areas with such unemployment rates. Based on redevelopment benefits computed for other areas in New England, the annual value of putting unemployed or underemployed people to work on a project of this magnitude would be about \$115,000. The benefit is not claimed at this time but is demonstrated to show that such a project could help towards alleviating a hard core unemployment problem.

TOTAL DAMAGE IN \$ 1,000 UNITS



	RANGE "A"			RANGE "B"			RANGE "C"			AVERAGE ANNUAL	
	1" = \$ 800			1" = \$ 2,000			1" = \$ 20,000			LOSS	BENEFITS
	AREA	LOSS	BEN.	AREA	LOSS	BEN.	AREA	LOSS	BEN.		
	13.0	10,400	—	19.57	39,140	—	6.67	133,400	—	182,940	—
PUMPING 8,400 C.F.S.	12.5	10,000	400	6.56	13,120	26,020	2.65	53,000	80,400	76,120	106,820

CHARLES RIVER INTERIM REPORT
 LOWER CHARLES RIVER
 DAMAGE FREQUENCY CURVE
 MUDDY RIVER
 NEAR CONFLUENCE WITH CHARLES
 MAY 1968
 DEPARTMENT OF THE ARMY
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS
 WALTHAM, MASS.

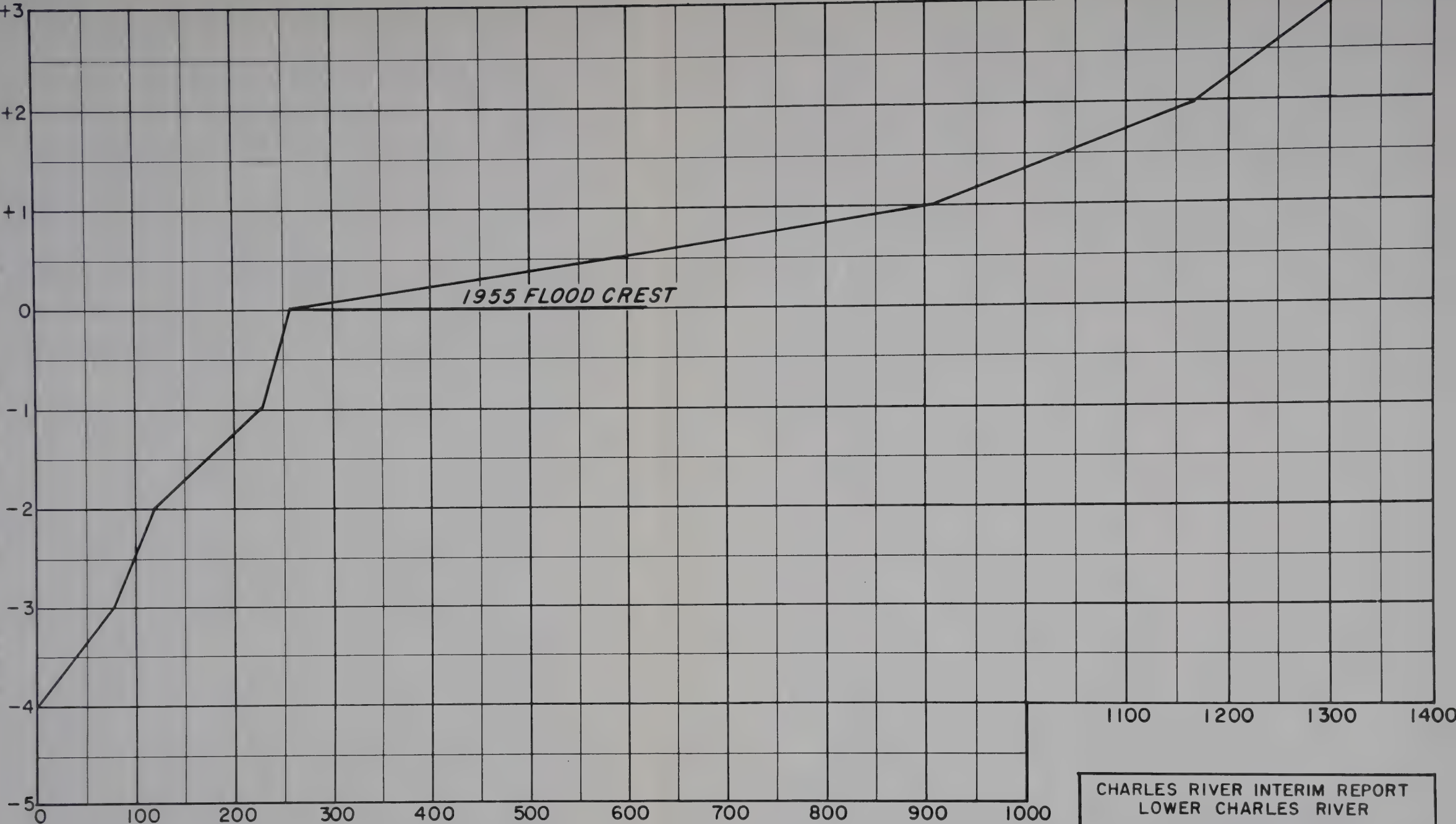
STAGE IN FEET REFERRED TO 1955 FLOOD CREST

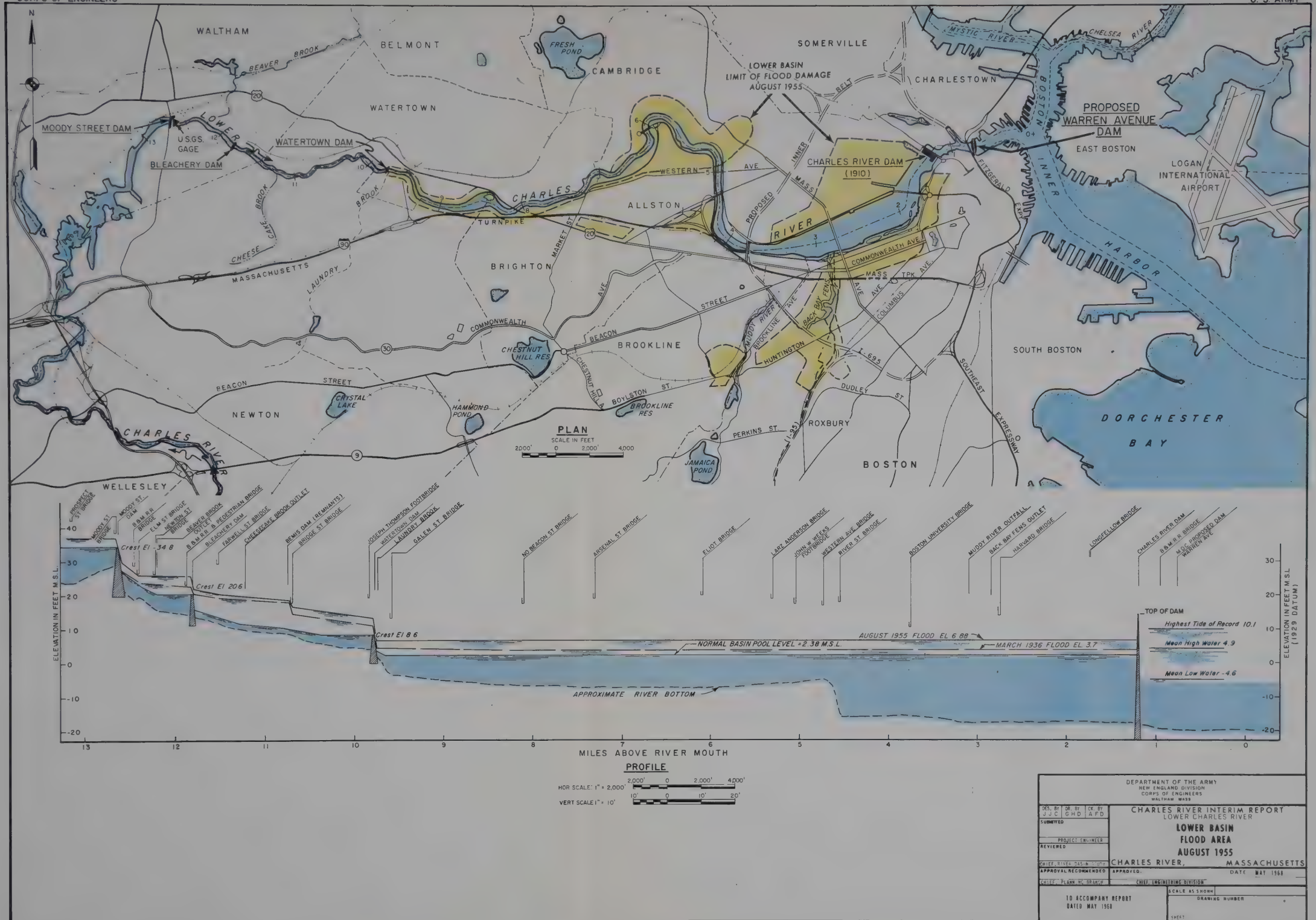
1955 FLOOD CREST

TOTAL DAMAGE IN \$1,000 UNITS

CHARLES RIVER INTERIM REPORT
LOWER CHARLES RIVER
STAGE DAMAGE CURVE
MUDDY RIVER
NEAR CONFLUENCE WITH CHARLES
MAY 1968
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. G-2





APPENDIX H

WATER SUPPLY AND WATER QUALITY

APPENDIX H

CHARLES RIVER WATERSHED STUDY
WATER SUPPLY AND WATER QUALITY
LOWER CHARLES RIVER REPORT AREA

Prepared by

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

Northeast Water Quality Management Center
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APPENDIX H

WATER SUPPLY AND WATER QUALITY

INTRODUCTION

1. PURPOSE AND SCOPE

This appendix provides information on the present water supply and water quality of the lower Charles River below Moody Street Dam, Waltham. This portion of the river and the area draining to it will be referred to in this report as the Lower Charles River Report Area.

2. LOCATION AND DESCRIPTION OF STUDY AREA

A. The Charles River Watershed

The Charles River watershed is located in eastern Massachusetts, bordering on the watersheds of the Mystic, Merrimack, Blackstone, Taunton, and Neponset Rivers. The total watershed drains about 307 sq. mi. (square miles). It is hour-glass in shape with a length of 31 miles and with widths varying from 6 to 15 miles. Elevations vary from 560 feet, msl, (mean sea level) along the southwesterly rim of the basin in Hopkinton to below 10 feet, msl, along the lower 8 1/2 miles of the Charles River (See Figure H-1).

The watershed includes all or portions of 5 cities and 30 towns. Within the watershed lies an important and highly developed portion of Metropolitan Boston and less developed but rapidly growing suburban and rural areas.

B. Lower Charles River Report Area

Of the total watershed, the Lower Charles River Report Area drains 58.2 square miles of tributary area between Moody Street Dam and the mouth of the Charles River. Between the Watertown Dam, located 2.7 miles downstream of Moody Street Dam, and the Charles River Dam, located near the mouth of the river, the normal design elevation of the Charles River is 2.38 feet, msl (108.0 Metropolitan District Commission Sewer Division base). This reach of the river is generally known as the Charles River Basin. The width of the river below Watertown Dam varies from 150 to 400 feet in the upper six miles to a maximum of 2,200 feet in the lower 2 1/2 miles. Water depths vary from 3 feet in parts of Watertown to a maximum depth of 38 feet in the lower part of the Basin. At normal pool elevation, the water surface area is approximately 700 acres and the capacity 10,100 acre-feet.

The cities and towns within the Lower Charles River Report Area are portions of Waltham, Watertown, Lexington, Arlington, Belmont, Newton, Cambridge, Brookline, Somerville, and Boston, some of the most highly developed areas in New England. The population residing within the Lower Charles Report Area in 1965 was approximately 590,000, about 70 percent of the total estimated 1965 watershed population of 850,000.

The present water uses in the Lower Charles River are shell, sail and power boating; fishing; water supply for power and industrial cooling; and environmental esthetics.

WATER SUPPLY

3. METROPOLITAN DISTRICT COMMISSION WATER DISTRICT

All cities and towns located within the Lower Charles River, except the City of Cambridge, obtain their water solely from the Metropolitan District Commission, which is supplied by sources outside the watershed. Cambridge has its own surface water supply in addition to connections to the Metropolitan District Commission.

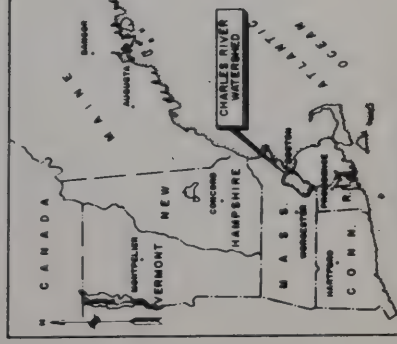
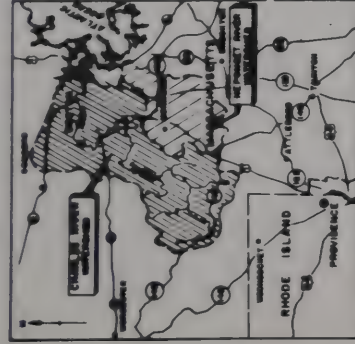
Thirty-one cities and towns make up the Metropolitan District. The 1965 population of the District was 1,793,000, and the average daily water consumption in 1965 was 227 mgd (million gallons per day).

The major source of water for the MDC is the Quabbin Reservoir in Central Massachusetts. It impounds the runoff from 284 sq. mi. of the Swift and Ware Rivers in the Connecticut River Basin. The reservoir has a capacity of 412 billion gallons, probably the largest reservoir in the world constructed solely for water supply purposes. Water from Quabbin flows through the Quabbin Aqueduct to the Wachusett Reservoir on the Nashua River. The Wachusett Reservoir with a capacity of 65.0 billion gallons impounds runoff from 107.7 sq. mi. of the South Branch Nashua River. From Wachusett, water is delivered to the consumer through a system of aqueducts and terminal and distribution reservoirs. The water is of a very high quality and the only treatment required is the addition of small amounts of chlorine and ammonia.

The present safe yield of the sources of supply to the Metropolitan system is 330 mgd. However, because of diversions from the system west of metropolitan Boston, the safe yield available for supply to the MDC does not greatly exceed 300 mgd. Recent studies conducted by a special State commission (Senate, No. 760 of 1962)

MYSTIC RIVER BASIN

(SHAWSHOEN)



MERRIMACK RIVER BASIN (SUDBURY-CONCORD)



have shown that by 1975, the water consumption will exceed 330 mgd because of increased demands of present users and the addition of expected communities to the District. Investigations are being made by the MDC to provide additional sources of water to meet future demands. One investigation raises the possibility of diverting water from the Millers River Basin to the Quabbin Reservoir to supplement the existing system. It is estimated that the safe yield of the Metropolitan System would be increased to 519 mgd by such a diversion.

Another possible source of water that may be diverted to the Quabbin Reservoir has been proposed by the Western Massachusetts Electric Company. In connection with the Northfield Mountain pumped storage project, it has been estimated that an average annual quantity of 72 mgd of water from the Connecticut River could be made available for water supply.

4. CITY OF CAMBRIDGE WATER SUPPLY

The main source of water for the City of Cambridge is the Hobbs Brook, Stony Brook, and Fresh Pond reservoir system. The usable storage capacity and drainage area of the impoundments are shown in Table H-1 below.

TABLE H-1

USABLE STORAGE CAPACITY AND DRAINAGE AREAS
OF CAMBRIDGE WATER SUPPLY SYSTEM

Reservoir	Usable Storage Capacity (mg)	Net Drainage Area (sq. mi.)
Hobbs Brook	2700	6.25
Stony Brook	400	17.35
Fresh Pond	1300	1.0

Raw water released from Hobbs Brook Reservoir flows in an open channel to Stony Brook Reservoir. Then by gravity water is carried to the Fresh Pond weir chamber in Cambridge. Adjacent to Fresh Pond, the City operates a 22 mgd filtration plant. Treatment includes coagulation, sedimentation, filtration, aeration, postchlorination, and pH adjustment for corrosion control.

Additional water for the City of Cambridge is supplied by the MDC. In 1965, the average daily consumption of Cambridge was 22.3 mgd. Of this 16.8 was obtained from the city supply and 5.5 mgd from the MDC.

5. PRIVATE WATER USE

The vast majority of industries in the Lower Charles River Report Area are supplied with water from the MDC system. However, some water is taken directly from the river largely for cooling purposes. The daily withdrawal is approximately 130 mgd of which 1.8 mgd is not returned to the river.

WATER QUALITY

6. MDC AND MUNICIPAL SEWERS AFFECTING THE LOWER CHARLES RIVER

A. General

Forty-two cities and towns, including all those of the Lower Charles Report Area, contribute wastes to the Metropolitan District Commission Sewage District. Final disposal of all sewage of the District, after treatment, is the Atlantic Ocean, through two major systems: the South Metropolitan System and the North Metropolitan System.

The South Metropolitan System collects the wastes of 22 cities and towns, including Waltham, Watertown, Newton, Brookline, and portions of Boston in the Lower Charles. Sewage from this system is treated at the Nut Island sewage treatment plant which was placed in operation in 1952. The treatment processes consist of prechlorination, screening, preaeration, primary sedimentation and postchlorination. Modified high rate digestion is used for treatment of raw sludge. The digested sludge is disposed into tidal waters 4.2 miles from the treatment plant. In the 12-month period from July 1965 to June 1966 the average flow to Nut Island was 119 mgd from a total sewered population of about 838,000.

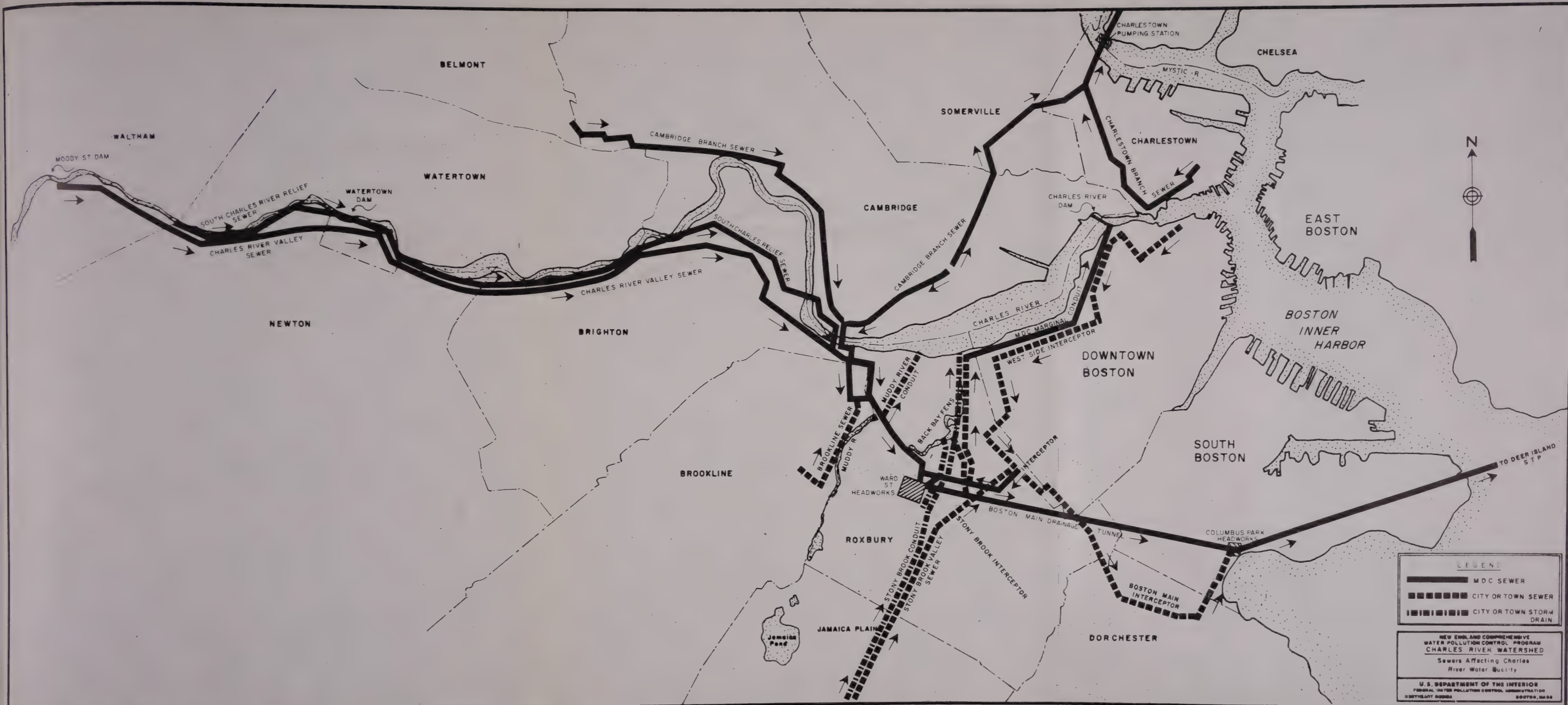


FIGURE -2

Twenty communities, including Lexington, Belmont, Cambridge, Arlington, Somerville, and portions of Boston in the Lower Charles discharge wastes to the North Metropolitan System. The sewage from this system is conveyed to Deer Island where a new primary treatment plant will soon be placed in operation. In 1967 there was no treatment at Deer Island. In 1965 the average sewage flow to Deer Island was about 130 mgd from a total sewered population of 701,600.

B. Sewers Affecting the Quality of the Charles River

Along both banks of the Charles River at times of storm flow, when major interceptors reach their capacity, the local sewers overflow directly to the Charles River Basin or to tidewater. There are approximately 52 points of sewer relief within the Lower Charles River. Forty-three overflows are located above the Charles River Dam and nine between the Charles River Dam and the proposed Warren Avenue Dam. Some of the overflows are activated by storms of very low rainfall intensity, particularly along the Cambridge side of the Charles River. The main trunk sewers and conduits which affect the Lower Charles River are the Charles River Valley Sewer, the South Charles Relief Sewer, the City of Boston West Side Interceptor, the Boston Marginal Conduit, the Cambridge Branch Sewer and the Charlestown Branch Sewer. These sewers are shown on Figure H-2.

(1.) Charles River Valley Sewer and South Charles Relief Sewer (MDC)

The Charles River Valley Sewer originates in Waltham and travels in an easterly direction through Newton and Brighton to the Ward Street Headworks in Boston. There are 16 points of overflow to the Lower Charles River from the Charles River Valley Sewer. A new South Charles Relief Sewer originates at the Waltham-Newton line and follows a path generally parallel to the Charles River Valley Sewer and also discharges at the Ward Street Headworks. This sewer was activated during the summer of 1967. It is designed to intercept all the runoff from a hypothetical five-year storm based on precipitation records compiled at Boston Logan Airport from September 1, 1949 to August 31, 1954.

(2.) Stony Brook Conduit and Stony Brook Valley Sewer (City of Boston)

The Stony Brook Conduit and the Stony Brook Valley Sewer originate in West Roxbury and run northward to Tremont Street. The Stony Brook Conduit, primarily a storm drain, enters two parallel sewers known as the Commissioners Channels. These channels overflow high storm flows to the Back Bay Fens and low storm flows to the Charles River through one of two parallel Foul-Flow Channels which run northward along the Fens to a Gate House near the Charles River.

The Stony Brook Valley Sewer discharges wet-weather flow to the Old Stony Brook Conduit, a system of two parallel sewers, which also overflows high wet-weather flows to the Back Bay Fens. Low wet-weather flows are discharged through the second Foul Flow Channel which discharges to the Boston Marginal Conduit. Dry weather flow from the Stony Brook Valley Sewer discharges to the Stony Brook Interceptor which connects to the Boston Main Interceptor. A new MDC relief sewer takes all the flow contributed by the Stony Brook Valley Sewer and the West Side Interceptor to the Ward Street Headworks.

(3.) West Side Interceptor (City of Boston)

The West Side Interceptor originates in the North End and runs generally west toward the MBTA Science Park Station and turns south to Beacon Street. The Interceptor then runs parallel to the Charles River and finally connects to the Boston Main Interceptor and to the Ward Street Headworks. There are several connections which flow from the West Side Interceptor to the Boston Marginal Conduit.

(4.) Boston Marginal Conduit (MDC)

The Boston Marginal Conduit originates west of Massachusetts Avenue at the Fens and extends along the Charles River and discharges into tidewater downstream of the Charles River Dam. It receives flow from combined sewers in the Back Bay area and from Beacon Hill. There are approximately six overflows into the Charles River from this conduit above and two below the Charles River Dam.

(5.) Brookline Sewer (Town of Brookline)

Most of the sewage of Brookline is discharged to the South Charles Relief Sewer and the Charles River Valley Sewer which pass through the Northeastern corner of Brookline. There are two overflows from Brookline sewers into the waters of the Charles River Basin. One overflow is to the Muddy River and the other to the Charles River.

(6.) Cambridge Branch Sewer (MDC)

The Cambridge Branch Sewer originates at the Cambridge-Belmont municipal boundary and passes through Cambridge along the north side of the Charles River to the Boston University Bridge, thence to the Ward Street Headworks, Boston. Another portion of that sewer between Boston University Bridge and Main Street, Cambridge also flows back from Main Street to the Ward Street Headworks.

North of Main Street, a third section through Somerville eventually connects with the North Metropolitan sewer which flows to Deer Island. There are approximately 17 overflows into the Charles River Basin from this system and two more including the Cambridge Marginal Conduit between the Charles River Dam and the proposed Warren Avenue Dam. The Cambridge Marginal Conduit extends from Binney Street in Cambridge, thence parallel to the Charles River Basin, and discharges to tidewater downstream of the Charles River Dam.

(7.) Charlestown Branch Sewer (MDC)

There are also five overflows between the Charles River Dam and the proposed Warren Avenue Dam from the Charlestown Branch Sewer, which circles Charlestown and connects with the Cambridge branch sewer and thence, via the Charlestown pumping station, to Deer Island.

7. PLANS TO REDUCE FREQUENCY OF COMBINED OVERFLOWS TO THE LOWER CHARLES RIVER

The MDC, as part of its overall plan to provide adequate facilities for treating the wastes from the Metropolitan Area, has instituted a program to maintain the waters in the Metropolitan Area in an healthful and attractive condition. The elimination or reduction of the present frequent overflows of combined sewage to the Charles River Basin has received a major priority.

Plans are being made or already completed to practically eliminate the overflows of combined sewage above B. U. Bridge from the Cambridge Branch and the Charles River Valley Sewers. The construction of new relief sewers is being designed to carry the flow from a rainfall with an estimated recurrence interval of five years. The present Cambridge Branch sewer between B. U. Bridge and Main Street, Cambridge is to be abandoned and a new relief sewer constructed which will take the flow back to B. U. Bridge. Also, the Brookline Town sewer is to be connected with the Charles River Valley sewer in such a way that storm flows from this system will be diverted to B. U. Bridge.

Near B. U. Bridge a storm water detention and chlorination station is to be constructed. Excess storm flows from the North Charles, South Charles and Brookline systems will be discharged to the Basin at the new facility after settling and chlorination. The estimated total five-year design storm flow at B. U. Bridge is 292.8 mgd. Of this flow, 130.2 mgd will be carried to Deer Island via the Ward Street Headworks and 162.2 mgd will be treated at the B. U. Facility. The design storm flow to the detention facility

will be 233.1 mgd to allow for 70.5 mgd from the main Brookline sewer. Rainfalls that produce flows in excess of 292.8 mgd will cause surcharging in the North and South Charles Relief sewers and consequent combined sewage overflow above B. U. Bridge. However, this is rated to occur on the average of once in five years. Overflows to the detention and chlorination facility will begin when the intensity of rainfall is equivalent to 0.22 inches per hour for a one hour duration storm. This initial overflow will be from the North Charles Relief sewer and the Brookline sewer. The frequency of overflow to the B. U. facility has been estimated to be 22 times per year with durations ranging from one to thirteen hours. These estimates were prepared by Elson T. Killam, Hydraulic and Sanitary Engineers, on the basis of rainfall records from September 1, 1949 to August 31, 1954.

Plans are also being made to reduce the frequency of overflow of combined sewage to the Charles River from other sewers. A relief sewer that diverts the flow from the Stony Brook Interceptor and the West Side Interceptor to the Ward Street Headworks has recently been activated. Some reduction in overflows will be provided by these two sewers.

The Cambridge Branch Sewer north of Main Street, Cambridge, and the Charlestown Branch sewer, will be greatly relieved as a result of diverting all flow in the Cambridge Branch sewer south of Main Street to the Ward Street Headworks.

The Boston Marginal Conduit (MDC) discharges on the harbor side of the Charles River Dam. At times of high tide and heavy rainfall, the conduit will surcharge causing combined sewage overflow to the Charles River. The MDC plans to construct a sewage pumping station on the Boston Marginal Conduit so that storm flows may be discharged to the harbor below the proposed Warren Avenue Dam at all tides.

8. WATER QUALITY OF THE LOWER CHARLES RIVER

A. General

During the period of July 14 to August 18, 1967, field investigations of the Charles River and Boston Harbor were conducted by personnel of the Technical, Advisory and Investigations Branch, FWPCA. Seventeen sampling stations were established on the Charles River and its tributaries between Milford and the Charles River Dam. Bacteriological, biological and chemical studies were conducted.

Four of these sampling stations were located within the Lower Charles River Report Area. The location of these stations are as follows: Moody Street Bridge, Waltham (Station C-14), Joseph U. Thompson Foot Bridge, Watertown (Station C-15), John Weeks Foot Bridge, Cambridge (Station C-16) and Longfellow Bridge, Boston (Station C-17). A summary of the results appears in Attachment A.

The Metropolitan District Commission is presently conducting a sanitary survey of the Charles River Basin to evaluate the effect of the new relief sewers and chlorination station on the quality of the Charles River. The MDC sampling program was established on November 1966. Samples are collected for analysis at eight locations on a monthly basis. The locations of the MDC and FWPCA stations are shown on Figure H-3.

B. Bacterial Determinations

Water polluted by sewage usually contains enormous numbers of coliform bacteria that occur typically in feces and excreta. These bacteria, while not usually harmful in themselves, are used as indicator organisms of the probable presence of pathogenic bacteria. These pathogens if ingested can cause gastro-intestinal diseases. As the densities of pathogenic bacteria are reduced through waste treatment, the hazards of contracting disease are proportionately reduced. The presence of fecal coliform bacteria is positive proof of fecal pollution and since no satisfactory method has been available to differentiate between the fecal coliform organism of man and animals, it is necessary to consider all fecal coliform organisms as indicators of hazardous contamination. When total coliform concentrations exceed an average of 1000 organisms/100 ml during a monthly sampling period, bathing and other water contact sports and, in most cases, use as a public water supply are prohibited by the State of Massachusetts.

Gross bacterial pollution was evident in the Lower Charles. The geometric mean of total and fecal organisms analyzed by the FWPCA are shown on Table H-2. The number of total and fecal coliform organisms increased steadily from Moody Street Bridge to a maximum at John Weeks Foot Bridge. The high concentrations of total and fecal coliform organisms found demonstrate that large quantities of sewage are added to the Charles River. In addition, Salmonella typhimurium was isolated from the river at Longfellow Bridge. This organism is pathogenic to man, is an intestinal organism and is further proof of the unwholesomeness of the Charles River Basin from a bacteriological standpoint.

TABLE H-2

LOWER CHARLES RIVER STATIONS
GEOMETRIC MEAN OF TOTAL AND FECAL COLIFORM
ORGANISMS PER 100 MILLILITERS

Station	Total Coliform Org./100 ml.	Fecal Coliform Org./100 ml.
C - 14	1,790	213
C - 15	7,570	760
C - 16	221,000	26,400
C - 17	16,500	952

As previously mentioned, a new South Charles Relief Sewer was activated in August 1967. The activation of this sewer was designed to reduce the quantity and frequency of overflows to the Charles River that occurred from the overloaded Charles River Valley Sewer between Waltham and B. U. Bridge. Results of the MDC analyses indicate a significant reduction of total coliform organisms between Watertown Dam and Eliot Bridge because of the activation. These results are shown on Table H-3.

Nevertheless, the results show that between Watertown Dam and Eliot Bridge, the total coliform concentrations are still substantial. On December 12 and 13, samples were collected by FWPCA personnel at thirteen stations between Watertown Dam and Eliot Bridge, and fecal coliform organisms were measured. December 12 was a period of heavy rain, and fecal coliforms varied from 710 organisms/100 ml. at Watertown Dam to over 1500 organisms/100 ml. above Eliot Bridge. On December 13, a mild, sunny day, fecal coliform concentrations varied from less than 20 organisms/100 ml. near Arsenal Street Bridge to over 1,000 organisms below Watertown Dam and at Eliot Bridge. These results show there are still waste discharges of sewage origin reaching the Charles River in this stretch. It would appear that there are illegal or unknown connections of sanitary sewers to storm drains or that some sanitary sewers have not



LEGEND

C-00

FWPCA SAMPLING STATION

MDC

MDC SAMPLING STATION

NEW ENGLAND COMPREHENSIVE
WATER POLLUTION CONTROL PROGRAM
CHARLES RIVER WATERSHED
LOCATION OF SAMPLING STATIONS
LOWER CHARLES

U.S. DEPARTMENT OF THE INTERIOR
REGIONAL WATER POLLUTION CONTROL ADMINISTRATION
BOSTON, MASS.

been intercepted by the new relief sewer. The communities of Waltham, Watertown and Newton have separate systems and there are many storm drains that discharge to the Charles River from these municipalities.

TABLE H-3

CHARLES RIVER BASIN

EFFECT OF ACTIVATION OF SOUTH CHARLES RELIEF SEWER
ON THE WATER QUALITY

Station	Before Activation ¹	After Activation ²
	Geometric Mean Total Coliform Org./100ml.	Geometric Mean Total Coliform Org./100ml.
Watertown Dam	22,400	2,440
North Beacon Street Br.	40,800	7,100
Eliot Br.	84,600	20,200
Western Avenue Br. ³	53,300	20,200
B. U. Br. ³	54,700	78,500

1. Geometric mean of three samples collected June, July, and Aug., 1967.
2. Geometric mean of three samples collected Sept., Oct., and Nov., 1967.
3. Influenced by overflows from the Cambridge Branch Sewer.

C. Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) Relationship

Sewage and many industrial wastes contain organic matter which exerts an oxygen demand on the receiving waters in the process of decomposition. In the biochemical degradation of the organic material, the oxygen derived from the atmosphere and dissolved in the water is reduced below its normal level of concentration. Large concentrations of the oxygen-demanding material cause an excessive reduction of the available oxygen dissolved in the water resulting in the reduction of desirable aquatic life and fish populations. If a complete depletion of the dissolved oxygen available occurs, offensive odors result.

Oxygen is supplied to waters from the atmosphere through natural reaeration. The strength of organic pollutants is generally measured by the amount of oxygen removed from the water in five days under controlled laboratory conditions (5 day 20°C. BOD). The pollutants however continue to remove oxygen from the water over a greater time before the demand is completely satisfied. The dissolved oxygen content of a stream (DO) receiving wastes from a single source is progressively reduced at each successive downstream point for as long as the demand for oxygen exceeds the reaeration capabilities of the stream.

Between station C-14 and C-15, the average BOD₅ increased steadily from 3.4 to 4.1 mg/l and then dropped to 2.1 mg/l at station C-17. The average DO increased from 7.2 mg/l at station C-14 to 8.1 mg/l at station C-15 and then decreased steadily to 5.6 mg/l at station C-17. Table H-4 shows the average and minimum DO concentrations and average and maximum BOD₅ concentrations analyzed by the FWPCA.

Results of analyses conducted by the MDC show a wide variability in DO and BOD concentrations. At Eliot Bridge, dissolved oxygen values of 0 mg/l and 0.4 mg/l were measured on January 25, 1967 and December 6, 1966. The BOD₅ concentrations measured on these dates were 36.0 and 14.4 mg/l, respectively. Values of DO as low as 0.8 mg/l and 0.6 mg/l were measured at Western Avenue Bridge and North Beacon Street Bridge. Relatively high values of BOD₅ and other low dissolved oxygen concentrations have been measured throughout the Basin on various dates.

It is apparent that large quantities of organic wastes are entering the Charles River from within the Report Area. Combined sewer overflows and urban runoff are the main sources of waste in this reach. The DO values reported are quite variable and do limit the uses of the Basin. Obnoxious odors at times make the river aesthetically objectionable. Desirable game fish are also limited by low DO concentrations.

TABLE H-4

LOWER CHARLES RIVER STATIONS
DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND
CONCENTRATIONS

Stations	Avg. D.O. (mg/l)	Min. D.O. (mg/l)	Avg. BOD ₅ (mg/l)	Max BOD ₅ (mg/l)	Avg. Depth of Collection (ft)
C-14	7.2	5.9	3.4	4.4	4
C-15	8.1	5.8	3.7	5.9	1.5
C-16	6.1	4.2	4.1	7.3	4
C-17	5.6	3.6	2.1	2.9	5

D. Temperature

The water temperatures throughout the Lower Charles River were relatively constant. The average temperatures varied from 24.6° C at stations C-14 and C-17 to 24.8 at station C-15 and 24.9° C at station C-16. The maximum temperatures reported at each station occurred on July 31 and the minimum temperatures except for station C-15 occurred on August 15. At station C-15 the August 15 temperature was the second lowest. July 31 followed a week of relatively warm weather with a lot of sunshine, while August 15 followed a relatively cool period with little sunshine. These results indicate that the climate is the most important factor in fluctuations of water temperature in the Lower Charles River above Longfellow Bridge. The maximum temperature measured by FWPCA in the Lower Charles was 27° C; however, the water temperature in previous years has reached values as high as 29° C.

Below Longfellow Bridge, approximately 72 mgd of heated cooling water effluent are returned to the Charles River by the Cambridge Electric Light Company. The temperature rise through the plant averages 8.3° C for 16 hours a day and 4.4° C during the remaining 8 hours. The average rise in temperature of the Charles River

between Harvard Bridge (above the Cambridge Electric Light Company Plant) and the Charles River Dam averaged 0.9°C based on 18 measurements conducted by the MDC between November 1966 and November 1967.

E. Salinity

The salt water content in the Charles River Basin fluctuates periodically throughout the year. Generally, the salt content increases steadily during the summer and early fall because of increased number of lockings at the Charles River Dam and low fresh water inflows. During prolonged dry spells when inflow into the Basin is exceeded by the losses from the Basin, it has been necessary to add quantities of salt water to maintain adequate Basin levels. During late fall or early spring following high river inflows the salt water content then decreases. For example, in 1967 the chloride content near the surface of the Charles River on the upstream side of the Charles River Dam varied from 185 mg/l on April 11, 2,200 mg/l on October 2 and then decreased to 850 mg/l on December 12.

Numerous chloride tests show a substantial stratification throughout the Basin between Watertown Dam and the Charles River Dam, particularly in the late summer and early fall. A stagnant salt water wedge is formed on the bottom of the river because of the greater density. Because of this wedge, vertical circulation of water and absorption of oxygen become greatly reduced. Due to the lack of oxygen, anaerobic respiration of settled organic matter at times has caused highly objectionable odors. Table H-5 shows the results of a typical salinity profile of the Basin conducted in August 1963. On this date DO concentrations were also determined. As expected, the results show high concentrations of chlorides and the absence of DO at lower depths.

F. Biological Determinations

(1.) Bottom Organisms

Bottom dwelling organisms are important indicators of pollution. Different types of organisms respond in various ways to changes that may occur in the environment. Some organisms cannot survive any appreciable degradation in water quality while others can survive and multiply in extremely degraded waters. In general, unpolluted streams support a wide variety of types of organisms but a relatively few of each type because of the danger of predators and competition for food and living space. In polluted streams the opposite is true. Most predators cannot survive because of the low quality. Living space and food supply is no problem for the organisms that can live in organic sludge. Therefore, large numbers of a few pollution tolerant species such as sludgeworms exist. If the DO is completely depleted no bottom organisms will survive.

TABLE H-5

CHARLES RIVER BASIN
CHLORIDE AND DISSOLVED OXYGEN PROFILE¹

Station	Depth (ft)	Chloride (mg/l)	DO (mg/l)
Charles River Dam	Surface	6,600	12.5
	5	6,500	11.0
	10	11,000	0.0
	15	13,900	1.9
	Approx 16 (bottom)	15,200	0.0
Charlesgate	Surface	5,600	11.6
	5	5,700	8.8
	Approx 8 (bottom)	8,600	0.0
Harvard Bridge	Surface	5,900	12.1
	5	6,000	11.2
Eliot Bridge	Surface	3,300	1.7
	5	6,500	4.0
	10	9,800	0.0
	15	10,400	0.0
	Approx 16 (bottom)	10,300	0.0

¹ Samples collected on August 22, 1963 by Thomas J. Rinaldo, Framingham, Massachusetts

In the Lower Charles River, wastes discharged from combined sewers and urban runoff effected a reduction in the number of species of clean water organisms and a significant increase in pollution tolerant sludgeworms. Only one kind of clean water organism and sludgeworm populations exceeding 100 per square foot were found at stations C-14 and C-15 which indicates substantial pollution in these reaches. Only one organism was found at station C-16, and at station C-17 no bottom dwelling organisms were found. The paucity of such organisms suggested that toxic conditions prevailed, thereby precluding establishment of bottom associated animal life.

Based on previous analyses, it is evident that the DO is completely depleted at the bottom of the Charles River in the lower reaches of the Basin. The high salt water content in the Basin may also have a toxic effect on bottom dwelling organisms. Black oozy muds that emitted foul odors and contained oily residues were found at stations C-16 and C-17, and the surface of the river was pockmarked with bursting bubbles of hydrogen sulfide, which is indicative of septic conditions.

(2.) Nutrients and Aquatic Plants

Nitrogen and phosphorus stimulate aquatic plant growths. Some aquatic plants can utilize organic forms of nitrogen and certain others such as blue-green algae can fix atmospheric nitrogen. Most, however, depend on soluble inorganic forms of nitrogen for growth and maintenance and will require soluble phosphorus. When sufficient quantities of inorganic nitrogen and phosphorus are available and other factors such as light, trace elements, temperature and substrate are not limiting, abundant growths of aquatic plants occur in fresh water lakes and streams.

Average inorganic nitrogen in the Charles River increased from 0.6 mg/l at station C-14 to 0.9 mg/l at station C-17. Average soluble phosphorus increased from 0.12 mg/l at station C-14 to 0.18 mg/l at station C-17. The increases were caused primarily by combined sewage and storm water overflows that occur along the entire length of the Lower Charles River.

Rooted aquatic plants were not observed in the Lower Charles. However, abundant phytoplankton populations were present. Phytoplankton populations varied from 19,800 cells per milliliter at station C-14 to over 10,000 cells per milliliter at all other stations. These concentrations unduly increase the turbidity and color of the stream, thereby reducing its aesthetic and recreational value. The phytoplankton present also interfere with industrial water use in the Basin. At least two industries that use Charles River water for cooling purposes employ chlorination to control algae growth within the cooling system.

(3.) Bottom Deposits

Municipal sewage and certain industrial wastes contain substantial quantities of organic nitrogenous and carbonaceous materials that settle and form sludge deposits when discharged to receiving waters. These deposits decompose and consume oxygen from the overlying water causing a decrease in the amounts of oxygen available for aquatic life such as fish and fish food organisms.

Percentages of organic carbon and organic nitrogen were determined from dried river bed samples. Sludge deposits were not found at station C-14 above Moody Street Dam. Below station C-14, the many combined sewer overflows that are located along both banks of the river have deposited highly carbonaceous and nitrogenous wastes. The organic carbon content of these sludges exceeded 12 percent, and the organic nitrogen ranged from 0.70 to 0.84 percent, indicating part organic pollution (See Attachment A).

G. Other Analyses

In addition to the above determinations, the FWPCA also measured pH, turbidity, alkalinity and suspended solids. The MDC measured pH, odor, chlorine demand and residual, grease, total solids and suspended solids.

H. Summary of Present Water Quality

Combined sewer discharges and urban runoff have severely degraded the quality of the Lower Charles River. High bacterial populations in the river make the water unsuitable for swimming and other water contact sports. Sludge banks have been formed on the bottom where the DO has been depleted, producing septic conditions and periodic foul odors. Floating oil and debris is displeasing and has caused damage to boats. High algal populations add color to the water and interferes with industrial water use. Many and vigorous complaints objecting to these degraded conditions have been made.

I. Future Water Quality

The MDC program to reduce the frequency of combined overflows to the Charles River and to provide storm flow treatment will significantly decrease or reduce bacterial and organic pollution, and will also diminish the accumulation of sludge deposits on the river bottom.

The Massachusetts Division of Water Pollution Control has established the following classifications for the Charles River: Class B between Moody Street Dam and Watertown Dam and Class C from the Watertown Dam to the Charles River Dam. Class B waters are suitable for bathing and recreational purposes including water contact sports; and provide excellent fish and wildlife habitat, and excellent aesthetic value. Class C waters are suitable for recreational boating, are suitable habitat for wildlife and common food and game fishes indigenous to the region and are of good aesthetic value. The Massachusetts standards of water quality appear in Attachment B. An active program to enforce these standards will result in a further major improvement in the river's water quality.

Construction of the proposed dam at the Warren Avenue Bridge with modern locking facilities and low level discharges would provide improved control over salt water intrusion to the Basin. This in turn would permit improved mixing of waters and distribution of Oxygen. Facilities to eliminate overflows from the combined overflow sewers located between the Charles River Dam and the new site are an essential part of the dam construction if degradation of water quality in the Basin is to be avoided.

Proper implementation of present and proposed programs will improve the Charles River water quality. Additional measures may also be required depending upon population changes and the degree to which measures to prevent combined overflows are successful. Further consideration will be given to these and other future water quality problems, including the need for and value of low-flow augmentation, in the final report on the entire watershed.

ACKNOWLEDGEMENTS

The staff preparing this report gratefully acknowledges the cooperation of the following agencies which supplied much valuable information: The New England Division, Corps of Engineers; the Metropolitan Area Planning Council; the Metropolitan District Commission; and Water Resources Commission, Division of Water Pollution Control; and the City of Cambridge Water and Engineering Departments.

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ATTACHMENT 1

Results of Analyses of Samples
Collected in the Lower Charles River

<u>Sample Station No.</u>	<u>Description</u>	<u>River Mile</u>
C-14	Moody St. Bridge, Waltham	12.6
C-15	Jos. U. Thompson Foot Bridge	9.8
C-16	John Weeks Foot Bridge	5.1
C-17	Longfellow Bridge, Boston	1.7

Chemical and Bacteriological Results

SUMMARY OF FIELD DATA - Station C-14

Boston Harbor - Charles River Study
Massachusetts

Date	Time	Temp. °C.	Depth ft.	D.O. mg/l	B. O. D.		pH	Turb. Units	Color Units	Alkalinity mg/l	Suspended Solids		NO ₃ -N mg/l	Org-N mg/l	NH ₃ -N mg/l	Phosphorus		Coliform Bacteria	
					2-Day mg/l	5-Day mg/l					Total mg/l	Volatile mg/l				Total mg/l	Soluble mg/l	Total	Fecal
7-17-67	1435	24.0	5	6.1	1.59	2.70	6.8	8.0	120	22.3	18	10	0.4	1.0	0.26	0.26	0.16	1,700	230
19	0815	23.0	4	6.2	1.38	2.62	6.8	6.0	100	24.0	8	6	0.4	1.3	0.23	0.24	0.15	900	130
21	1135	23.5	4	5.9	1.52	2.37	6.6	8.0	120	22.3	22	10	0.4	1.0	0.25	0.24	0.12	1,600	260
24	1210	25.5	4	6.9	1.39	2.45	6.9	10.0	140	22.5	15	4	0.4	0.9	0.19	0.26	0.16	400	60
25	1225	26.0	4	6.8	1.94	3.51	6.8	8.0	120	25.4	20	7	0.5	1.0	0.13	0.24	0.10	30,000	1,400
28	0830	25.0	4	6.4	1.90	2.72	6.8	10.0	120	30.0	18	6	0.4	1.2	0.09	0.25	0.14	2,600	290
31	1135	27.0	4	9.6	2.57	4.32	6.9	8.0	130	25.0	12	6	0.2	1.3	0.08	0.20	0.06	1,000	26
8-2-67	1135	25.0	4	6.1	2.08	3.49	6.9	15.0	120	31.5	32	11	0.2	1.2	0.25	0.25	0.11	200	140
4	1135	25.5	4	7.9	2.26	3.99	6.9	10.0	130	39.3	22	8	0.3	2.0	0.23	0.23	0.11	7,000	600
7	1140	23.5	4	7.0	2.37	4.22	6.9	10.0	110	23.2	20	7	0.5	1.3	0.22	0.23	0.09	6,000	960
15	1156	22.0	4	9.2	1.77	3.53	7.1	10.0	140	26.0	21	5	0.5	0.9	0.16	0.25	0.20	1,900	420
17	1220	25.0	4	7.5	2.55	4.45	6.9	10.0	130	25.9	25	10	0.4	1.2	0.06	0.22	0.10	1,800	190
18	1150	25.5	4	8.6	2.23	4.08	7.1	10.0	130	25.3	13	7	0.4	1.3	<0.1	0.20	0.10	900	5
MAX.		27.0		9.6	2.55	4.45	7.1	15.0	140	39.3	32	11	0.5	2.0	0.26	0.26	0.20	30,000	1,400
MIN.		22.0		5.9	1.38	2.37	6.6	6.0	100	22.3	8	4	0.2	0.9	0.08	0.20	0.06	200	26
AVG.		24.6		7.2	1.96	3.42	6.9	9.0	124	26.4	19	7	0.4	1.2	0.11	0.24	0.12	1,793	213

SUMMARY OF FIELD DATA - Station C-15

Boston Harbor-Charles River Study
Massachusetts

Date	Time	Temp. °C.	Depth Ft.	D.O. mg/l	B. O. D.		pH	Turb. Units	Color Units	Alkalinity mg/l	Suspended Solids		NO ₃ -N mg/l	Org-N mg/l	NH ₃ -N mg/l	Phosphorus		Coliform Bacteria Total/Fecal
					2-Day mg/l	5-Day mg/l					Total mg/l	Volatiles mg/l				Total mg/l	Soluble mg/l	
7-17-67	1455	25.5	3	8.7	2.19	3.87	7.0	10.0	120	23.7	25	12	0.5	1.1	0.21	0.26	0.15	32,000
19	0735	22.5	1.5	6.8	1.21	2.51	6.7	6.0	90	23.3	12	4	0.4	1.2	0.21	0.24	0.14	4,700
21	1150	24.0	1.5	7.8	1.74	2.71	6.8	9.0	120	24.0	23	8	0.5	1.0	0.24	0.26	0.16	7,200
24	1230	26.0	1.5	8.1	2.18	3.47	6.8	10.0	120	26.5	16	6	0.5	0.9	0.18	0.26	0.14	15,000
25	1245	26.5	1.5	7.0	3.32	4.99	6.8	15.0	120	22.8	24	6	0.6	1.1	0.16	0.20	0.10	19,000
28	0815	24.5	1.5	5.8	1.68	2.92	7.0	8.0	140	20.2	16	6	0.5	1.3	0.10	0.22	0.12	8,000
31	1150	27.0	1.5	8.3	2.26	3.66	7.2	2.0	120	27.0	20	5	0.3	1.0	-	0.23	0.11	4,300
8-2-67	1150	24.0	1.5	8.5	2.40	3.99	7.2	10.0	95	32.0	31	10	0.3	1.2	0.20	0.25	0.11	1,800
4	1150	24.5	1.5	7.3	5.86	> 5.86	6.9	20.0	95	24.7	37	11	0.4	1.3	0.24	0.27	0.11	67,000
7	1150	24.0	1.5	8.2	1.82	3.37	7.0	15.0	95	24.9	26	7	0.5	1.3	0.25	0.24	0.09	14,000
15	1210	23.0	1.5	9.8	1.47	3.25	7.3	9.0	120	27.8	19	9	0.5	1.0	0.16	0.34	0.15	3,400
17	1235	25.0	1.5	7.7	1.97	3.76	6.6	10.0	120	30.8	23	8	0.6	1.2	0.04	0.21	0.10	2,300
18	1210	25.5	1.5	11.0	1.59	3.28	6.9	30.0	120	26.6	32	5	0.7	1.5	0.2	0.27	0.10	1,900
MAX.	27.0			11.0	5.86	> 5.86	7.2	30.0	140	32.0	37	12	0.7	1.5	0.25	0.34	0.16	47,000
MIN.	22.5			5.8	1.21	2.51	6.6	2.0	90	20.2	12	4	0.3	0.9	0.04	0.20	0.09	1,900
AVG.	24.8			8.1	2.36	> 3.66	6.9	12.0	113	25.7	23	7	0.5	1.2	0.16	0.25	0.12	7,566

SUMMARY OF FIELD DATA - Station C-16

Boston Harbor-Charles River Study

Massachusetts

Date	Time	Temp. °C.	Depth Ft.	D.O. mg/l	B. O. D.		pH	Turb. Units	Color Units	Alkalinity mg/l	Suspended Solids		NO ₃ -N mg/l	Org-N mg/l	NH ₃ -N mg/l	Phosphorus		Coliform Bacteria	
					2-Day mg/l	5-Day mg/l					Total mg/l	Volatile mg/l				Total mg/l	Soluble mg/l	Total	Fecal
7-17-67	1520	26.5	5	5.2	2.47	4.03	6.8	5.0	120	35.0	14	10	0.5	1.1	0.52	0.28	0.18	220,000	4,000
19	0720	23.5	4	5.7	1.95	3.43	6.7	5.0	100	27.2	12	8	0.5	1.3	0.42	0.25	0.18	380,000	23,000
21	1210	24.0	4	5.6	2.32	3.77	6.6	6.0	140	27.0	16	6	0.5	1.1	0.42	0.26	0.18	38,000	3,000
24	1245	26.0	4	6.7	2.15	3.41	7.0	8.0	120	33.2	12	7	0.5	1.0	0.50	0.35	0.23	74,000	9,170
25	1305	26.5	4	6.6	2.30	4.15	6.8	6.0	120	29.0	11	5	0.5	1.0	0.44	0.23	0.17	21,000	10,000
28	0750	25.0	4	5.3	1.83	3.25	6.8	7.0	100	19.5	20	10	0.5	1.0	0.41	0.35	0.16	230,000	33,000
31	1210	27.0	4	4.2	1.70	2.85	6.9	6.0	110	36.5	10	4	0.3	1.3	0.58	0.37	0.22	93,000	8,100
8-2-67	1215	24.0	4	4.6	2.21	3.75	6.8	7.0	95	34.5	23	10	0.3	1.2	0.53	0.36	0.21	1,100,000	110,000
4	1215	25.0	4	7.2	5.45	> 7.29	6.9	10.0	100	31.7	15	6	0.3	1.3	0.53	0.36	0.19	700,000	80,000
7	1215	23.5	4	4.4	2.22	3.67	6.6	10.0	75	27.2	13	4	0.5	1.2	0.59	0.29	0.17	150,000	22,000
15	1230	22.5	4	8.1	2.76	4.53	7.0	7.0	100	30.0	16	10	0.4	1.0	0.27	0.32	0.18	110,000	12,000
17	1250	24.5	4	7.6	2.71	4.72	6.9	8.0	95	31.0	12	10	0.5	1.1	0.20	0.34	0.15	6,500,000	1,200,000
18	1235	25.5	2	8.6	2.75	4.33	7.0	7.0	110	32.9	22	7	0.5	1.2	0.2	0.22	0.11	510,000	15,000
MAX.	27.0			8.6	5.45	> 7.29	7.0	10.0	140	36.5	23	10	0.5	1.3	0.59	0.37	0.23	6,500,000	1,200,000
MIN.	22.5			4.2	1.70	3.25	6.6	5.0	75	27.0	11	4	0.3	1.0	0.20	0.22	0.11	21,000	3,000
AVG.	24.9			6.1	2.52	> 4.09	6.8	7.0	106	30.4	15	7	0.4	1.1	0.43	0.31	0.18	220,547	26,593

SUMMARY OF FIELD DATA - Station C-17

Boston Harbor-Charles River Study
Massachusetts

Date	Time	Temp. °C.	Depth Ft.	D.O. mg/l	B. O. D.		pH	Turb. Units	Color Units	Alkalinity mg/l	Suspended Solids		NO ₃ -N mg/l	Org-N mg/l	NH ₃ -N mg/l	Phosphorus		California Bacteriol. Total E.coli
					2-Day mg/l	5-Day mg/l					Total mg/l	Volatile mg/l				Total mg/l	Soluble mg/l	
7-17-67	1115	25.0	5	3.6	1.67	2.89	7.1	4.0	90	35.2	14	8	0.4	0.8	0.62	0.27	0.16	26,000
19	1110	25.5	5	7	0.74	1.63	6.7	2.0	90	33.7	6	4	0.4	1.0	0.60	0.26	0.21	4,000
21	0850	23.5	5	5.1	1.03	1.97	6.6	3.0	70	36.7	6	4	0.4	1.0	0.57	0.24	0.19	16,000
24	1325	25.0	5	3.6	0.99	2.04	7.0	4.0	70	46.8	8	6	0.3	0.8	0.66	0.27	0.16	14,000
25	0900	25.0	5	5.9	1.17	1.97	7.0	4.0	75	34.8	8	4	0.4	0.8	0.61	0.26	0.16	12,000
27	0655	25.9	5	5.9	0.86	1.74	7.0	4.0	100	36.8	7	4	0.5	1.0	0.55	0.25	0.18	6,800
31	1330	26.3	5	5.9	1.19	2.10	7.1	3.0	90	42.5	8	4	0.5	1.2	0.57	0.28	0.19	2,700
8-2-67	0855	26.0	5	5.4	1.71	2.42	7.1	3.0	80	45.6	11	6	0.4	0.9	0.54	0.29	0.20	7,000
4	1105	25.9	5	6.2	0.84	1.51	7.2	4.0	75	43.4	5	4	0.4	0.9	0.56	0.27	0.14	23,000
7	0810	23.2	5	4.6	1.28	2.34	6.9	8.0	22	39.0	9	4	0.4	1.0	0.60	0.27	0.16	225,000
15	1030	23.0	5	6.4	1.11	2.04	7.3	4.0	80	39.7	8	4	0.4	0.7	0.51	0.34	0.25	31,000
17	0530	23.7	5	9.6	0.33	1.71	7.1	5.0	65	36.8	7	6	0.4	0.9	0.22	0.26	0.12	59,000
19	1025	22.5	5	4.6	1.39	2.69	6.9	8.0	55	56.6	24	2	0.2	1.1	0.4	0.27	0.17	20,000
MAX.	24.4			9.6	1.71	2.89	7.3	8.0	100	56.6	24	8	0.5	1.2	0.66	0.34	0.25	205,000
MIN.	23.0			3.6	0.33	1.51	6.6	2.0	22	33.7	5	2	0.2	0.7	0.22	0.24	0.12	2,700
Avg.	24.6			5.6	1.10	2.08	7.0	4.0	74	40.6	9	5	0.4	0.9	0.54	0.27	0.16	16,515

Biological Results

Charles River Bottom Organisms
Kinds and Numbers Per Square Foot

August 1967

Organism	C-14	C-15	C-16	C-17
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Pollution Sensitive Organisms

Mayflies	2	-	-	-
<u>Caenis</u> sp.				
Caddisflies				
<u>Cheumatopsyche</u> sp.	-	Q ¹	-	-
Subtotal Numbers	2	1	0	0
Subtotal Kinds	1	1	0	0

Intermediate Organisms

Midges				
<u>Tanypus</u> sp.	Q	-	-	-
<u>Chironomus</u> sp.	66	-	Q	-
<u>Tanytarsus</u> sp.	Q	-	-	-
<u>Pentaneura</u> sp.	10	-	-	-
<u>Polypedilium</u> sp.	15	-	-	-
<u>Spaniotoma</u> sp.	5	Q	-	-
<u>Cricotopus</u> sp.	Q	-	-	-
Biting Midges				
<u>Bezzia</u> sp.	Q	-	-	-
Scuds				
<u>Hyallela</u> sp.	78	-	-	-
Sow-bugs				
<u>Asellus</u> sp.	3	-	-	-
Snails				
Physidae	-	Q	-	-
Planarians				
Planariidae	174	-	-	-
Leeches				
Hirudinea	79	128	-	-
Subtotal Numbers	434	130	1	0
Subtotal Kinds	12	3	1	0

Pollution Tolerant Organisms

Bloodworms				
<u>Chironomus</u> sp.	Q	-	-	-
Sludgeworms				
Tubificidae	120	256	-	-

Organism	C-14	C-15	C-16	C-17
Subtotal Numbers	121	256	0	0
Subtotal Kinds	2	1	0	0
Grand Total Numbers	557	387	1	0
Grand Total Kinds	15	5	1	0

1. Q = Present in qualitative samples; given an arbitrary value of 1 in the totals.

Charles River Phytoplankton

Numbers and Volume

August 1967

Station	Number Per Milliliter					Volume (parts per million)			
	Diatoms	Greens	Flagellate Greens	Other	Total	Diatoms	Greens	Flagellate Greens	Other T
C-14	17,200	1,800	700	100	19,800	8.55	8.52	3.50	3.20 2
C-15	12,700	900	300	-	13,900	5.04	1.10	1.58	-
C-16	4,700	5,400	700	400	11,200	2.97	43.90	1.05	.01 4
C-17	1.400	6,700	1,300	800	10,200	1.77	4.32	1.19	.09

Charles River Muds

Percentages of Organic Carbon and Organic Nitrogen

July - August 1967

Station	Percentage Organic Carbon	Percentage Organic Nitrogen
C-14	11.2	0.41
C-15	20.0	.74
C-16	18.4	.82
C-17	13.7	.70

ATTACHMENT 2

Massachusetts Water Quality Standards

COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION
DIVISION OF WATER POLLUTION CONTROL

WATER QUALITY STANDARDS

Adopted by the Massachusetts Division of Water Pollution Control on March 3, 1967, in accordance with the Provisions of Section 27 (4) of Chapter 21 of the General Laws, and in accordance with the procedure required by Chapter 30A of the General Laws, and after a public hearing held on February 17, 1967.

Filed with Secretary
of State on
March 6, 1967

STANDARDS OF WATER QUALITY

FRESH WATERS

Class A

Waters designated for use as public water supplies in accordance with Chapter 111 of the General Laws. Character uniformly excellent.

Standards of Quality

<u>Item</u>	<u>Water Quality Criteria</u>
1. Dissolved oxygen	Not less than 75% of saturation during at least 16 hours of any 24-hour period and not less than 5 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum	None allowable
3. Color and turbidity	None other than of natural origin,
4. Coliform bacteria per 100 ml.	Not to exceed an average value of 50 during any monthly sampling period.
5. Taste and odor	None other than of natural origin.
6. pH	As naturally occurs
7. Allowable temperature increase	None other than of natural origin.
8. Chemical constituents	None in concentrations or combinations which would be harmful or offensive to humans, or harmful to animal, or aquatic life.
9. Radioactivity	None other than that occurring from natural phenomena.

Class B

Suitable for bathing and recreational purposes including water contact sports. Acceptable for public water supply with appropriate treatment. Suitable for agricultural, and certain industrial cooling and process uses; excellent fish and wildlife habitat; excellent aesthetic value.

Standards of Quality

<u>Item</u>	<u>Water Quality Criteria</u>
1. Dissolved oxygen	Not less than 75% of saturation during at lease 16 hours of any 24-hour period and not less than 5 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oil-grease-scum.	None allowable
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria per 100 ml	Not to exceed an average value of 1,000 during any monthly sampling period nor 2,400 in more than 20% of samples examined during such period.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class and none that would cause taste and odor in edible fish.
6. pH	6.5 - 8.0
7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 83°F in warm water fisheries, and 68°F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4.0°F.

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|--------------------------|--|
| 8. Chemical constituents | None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class. |
| 9. Radioactivity | None in concentrations or combinations which would be harmful to human, animal or aquatic life for the appropriate water use. None in such concentrations which would result in radionuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans. |
| 10. Total phosphate | Not to exceed an average of 0.5 mg/l as P during any monthly sampling period. |
| 11. Ammonia | Not to exceed an average of 0.5 mg/l as N during any monthly sampling period. |
| 12. Phenols | Shall not exceed .001 mg/l at any time. |

Class C

Suitable for recreational boating; habitat for wildlife and common food and game fishes indigenous to the region; certain industrial cooling and process uses; under some conditions acceptable for public water supply with appropriate treatment. Suitable for irrigation of crops used for consumption after cooking. Good aesthetic value.

Standards of Quality

<u>Item</u>	<u>Water Quality Criteria</u>
1. Dissolved oxygen	Not less than 5 mg/l during at least 16 hours of any 24-hour period nor less than 3 mg/l at any time. For seasonal cold water fisheries at least 5 mg/l must be maintained.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum.	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
3. Color and turbidity	None allowable in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class, and none that would cause taste and odor to edible fish.
6. pH	6.0 - 8.5

- | | |
|-----------------------------------|---|
| 7. Allowable temperature increase | None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 83°F in warm water fisheries and 68°F in cold water fisheries, or in any case raise the normal temperature of the receiving water more than 4°F. |
| 8. Chemical constituents | None in concentrations or combinations which would be harmful or offensive to human, or harmful to animal or aquatic life or any water use specifically assigned to this class. |
| 9. Radioactivity | None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the appropriate water use. None in such concentrations which would result in radionuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans. |
| 10. Total phosphate | Not to exceed an average of 0.05 mg/l as P during any monthly sampling period. |
| 11. Ammonia | Not to exceed an average of 1.0 mg/l as N during any monthly sampling period. |
| 12. Phenols | Not to exceed an average of 0.002 mg/l at any time. |

Class D

Suitable for aesthetic enjoyment, power, navigation, and certain industrial cooling and process uses. Class D waters will be assigned only where a higher water use class cannot be attained after all appropriate waste treatment methods are utilized.

<u>Item</u>	<u>Specifications</u>
1. Dissolved oxygen	Not less than 2 mg/l at any time.
2. Sludge deposits-solid refuse-floating solids-oils-grease-scum.	None allowable except those amounts that may result from the discharge from waste treatment facilities providing appropriate treatment.
3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this class.
4. Coliform bacteria	None in such concentrations that would impair any usages specifically assigned to this class.
5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this class.
6. pH	6.0 - 9.0
7. Allowable temperature increase	None except where the increase will not exceed the recommended limits on the most sensitive receiving water use and in no case exceed 90°F.
8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal, or aquatic life for the designated water use.

9. Radioactivity

None in such concentrations or combinations which would be harmful to human, animal, or aquatic life for the designated water use. None in such concentrations which will result in radionuclide concentrations in aquatic life which exceed the recommended limits for consumption by humans.

NOTES:

1. All wastes shall receive appropriate waste treatment which is defined as secondary treatment with disinfection or its industrial waste treatment equivalent except when a higher degree of treatment is required to meet the objectives of the water quality standards, all as determined by the Division of Water Pollution Control. Disinfection from October 1 to May 1 may be discontinued at the discretion of the Division of Water Pollution Control.
2. Appropriate water supply treatment is as determined by the Massachusetts Department of Public Health.
3. These water quality standards do not apply to conditions brought about by natural causes.
4. Class B, & C waters shall be substantially free of pollutants that will:
 - (1) unduly affect the composition of bottom fauna
 - (2) unduly affect the physical or chemical nature of the bottom
 - (3) interfere with the spawning of fish or their eggs
5. The average minimum consecutive 7 day flow to be expected once in ten years shall be used in the interpretation of the standards except where noted.
6. The amount of disinfection required shall be equivalent to a free and combined chlorine residual of at least 1.0 mg/l after 15 minutes contact time during peak hourly flow or maximum rate of pumpage.

APPENDIX I
LETTERS OF COMMENT

APPENDIX I
LETTERS OF COMMENT

INDEX

<u>Exhibit No.</u>	<u>Agency</u>	<u>Letter dated</u>
I-1	U. S. Department of Health, Education and Welfare	20 May 1968
I-2	U. S. Department of the Interior, Federal Water Pollution Control Administration	1 May 1968
I-3	U. S. Department of the Interior, Fish and Wildlife Service	16 May 1968
I-4	U. S. Department of Transportation, Bureau of Public Roads	27 May 1968
I-5	Commonwealth of Massachusetts, Depart- ment of Public Works	23 May 1968
I-6	Metropolitan District Commission	23 May 1968
I-7	Charles River Citizen Advisory Committee	16 April 1968
I-8	Boston Redevelopment Authority	5 March 1968



DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

REGIONAL OFFICE

Region I

John Fitzgerald Kennedy Federal Building
Boston, Massachusetts 02203

PUBLIC HEALTH SERVICE

May 20, 1968

Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

I have received your letter of 17 May in which you describe a considered multiple-purpose dam project across the Charles River at the Warren Avenue site.

It is evident, after reviewing your proposal, that the new project will tend to improve rather than to impair the water quality of the Charles River Basin. The provisions in the plan for a pressure conduit from the proposed new MDC sewage pumping station to and through the new dam and to install feeder lines to conduct the flow of combined sewage in other existing lines to the pumping station are essential features to prevent the entry of polluted sewage flows to the newly created pool area between the existing and new dam.

The elimination of pollution in this extension to the existing basin is necessary if we are to prevent the aggravation of pollution in the present basin under today's conditions or those that will prevail upon completion of the contemplated MDC pumping station. Since the new pressure conduit will only serve to maintain "status quo" condition in the basin, no pollution abatement benefits should be assigned to this feature of the new dam proposal.

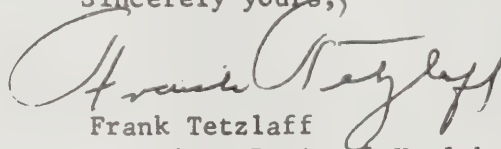
You indicate that the locks in the new dam will be operated in such a manner as to virtually eliminate salt water intrusion to the basin above the dam and you are correct in your understanding that the pollution abatement benefits derived from this operation are not readily evaluated. A lessening in the amount of salt water intrusion would, of course, have some beneficial rather than detrimental effect on the water quality. However, the degree of improvement is difficult to determine at this time and would be dependent on a number of factors such as the exact amount of reduction in intrusion that can be secured, the number of lockages, and flow or mix conditions in the basin extension below the present dam.

EXHIBIT I-1

As pointed out in the United States Public Health Service presentation February 15, 1968, at your meeting in Waltham, all steps possible should be taken to reduce pollution in the Lower Charles River. By so doing, existing recreational use thereof will be safer and a step forward will be taken towards greater recreational use.

I do thank you for this opportunity to comment on the pollution abatement aspects of your proposal for a new dam and appurtenant facilities at Warren Avenue and will be pleased to discuss this aspect of the project with your engineers at any time during the planning or final design state of the project.

Sincerely yours,

A handwritten signature in cursive script, reading "Frank Tetzlaff". The signature is written in dark ink and is positioned above the printed name and title.

Frank Tetzlaff

Associate Regional Health Director
Bureau of Disease Prevention and
Environmental Control



UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
240 Highland Avenue
Needham Heights, Massachusetts 02194

May 1, 1968

Mr. John W. Leslie
Chief, Engineer Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

In accordance with your letter of 5 April 1968, the water quality aspects of the proposed dam and pumping station in the Charles River Basin have been reviewed.

We believe the plan outlined in your letter to intercept all combined sewer overflow discharges between the Charles River Dam and Warren Bridge, and to divert the mixed sewage outside of the enlarged basin that will be created by construction of the new dam, is a sound suggestion. This interception is an essential step toward the achievement of the water quality standards for the Basin.


Discharging the intercepted mixed sewage and stormwater directly to Boston Harbor would not provide an adequate solution since the wastes would continue to deteriorate Harbor water quality. Combined sewer overflows below Warren Bridge from both the Charlestown Branch Sewer and the West Side Interceptor also add to the degradation. To protect or enhance the water quality of Boston Harbor, we recommend that consideration be given in the design phases of the project to a total system which would also intercept those overflows below Warren Bridge and which ultimately would provide adequate treatment to the overflows before discharge to the Harbor.

The reduction of salt water intrusion because of improved locking facilities, as mentioned in your letter, would probably have a beneficial effect on the water quality of the Basin. Other factors, however, are also involved. These include the effect of past salt and organic deposits on the bottom, the amount of organic matter which will continue to be deposited and the future mixing properties of the Basin. The net result of these factors cannot be estimated with reasonable certainty at this time. Nevertheless, we believe that an improvement in water quality can be achieved if stratification within the Basin is eliminated and organic deposits on the bottom are substantially reduced.

The Massachusetts Division of Water Pollution Control has the prime responsibility to implement, administer and enforce water quality standards in Massachusetts. It is therefore recommended that the design and construction phases of this project be coordinated with that agency with a view towards achieving a sound water quality management plan.

FOR THE REGIONAL DIRECTOR:

Sincerely yours,

A handwritten signature in dark ink, appearing to read "Walter M. Newman". The signature is fluid and cursive, with the first name "Walter" being more prominent.

Walter M. Newman, Chief
New England Comprehensive
Program

CC: Mr. Thomas McMahon, Director
Mass. Division of Water
Pollution Control



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

May 16, 1968

Colonel Remi Renier
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

We have been informed orally by your staff that a fish and wildlife report on the lower Charles River project is needed by the fourth week of May if it is to be included in the Corps of Engineers' report to Washington. Mr. Lind mentioned that he needed our comments on the Charles River Dam only, not the entire watershed.

Initial investigations reveal that the fish and wildlife resources of the lower Charles River Basin project cannot be adequately evaluated with consideration of the new dam alone. Ten dams impede anadromous fish movement, in varying degrees, in the Charles River. Each dam closes off a valuable portion of potential anadromous fish spawning habitat.

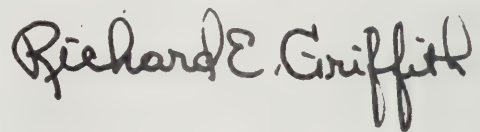
The construction of an adequate fish passage in the Charles River Dam is most important since it is located near the mouth of the river. However, large benefits are not readily apparent since a fish passage here provides immediate access to only 11 miles or 5½ percent of the river's spawning habitat -- namely that reach from Charles River Dam to the Moody Street Dam. If the habitat upstream from Moody Street Dam and upstream for each of the other eight or more dams on Charles River is considered simultaneously, 61 miles of anadromous habitat hang in the balance. Collectively, the availability of anadromous spawning habitat is very important whereas each individual segment may or may not be significant.

A detailed evaluation of the entire river system is required if the full fishery potential of the Charles River is to be realized.

The Connecticut River Comprehensive Study, which fell several months behind schedule due to personnel limitations, has been given high priority by the Fish and Wildlife Service in order to keep pace with the Corps' timetable on this important study from now until completion of the study. This and other program commitments will prevent assignment of personnel to work on the Charles River project immediately.

With these points in mind we will do our best to provide your office with a detailed fish and wildlife report on the Charles River project by July 5, 1968; it will not be possible to do so earlier.

Sincerely yours,

A handwritten signature in dark ink, reading "Richard E. Griffith". The signature is written in a cursive style with a large, prominent "R" and "G".

Regional Director



U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS
REGION ONE

612 J.F.K. FEDERAL BUILDING
BOSTON, MASSACHUSETTS 02203

IN REPLY REFER TO:

May 27, 1968

NEDED-R - Proposed North
Terminal Area Improvements
Charlestown Section of Boston
Warren Avenue Dam

Mr. John Wm. Leslie
Chief, Engineering Division
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

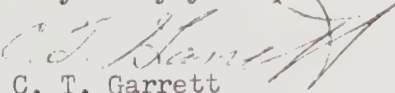
With reference to your letter of March 27, 1968 relative to the matter of the proposed Warren Avenue Dam, insofar as it concerns the U. S. Department of Transportation and the Federal-aid Highway system, we are attaching three copies each of the following documents:

Public Roads' letter to the State Department of Public Works dated April 17, 1968.

State's DPW letter to Public Roads dated May 23, 1968.

This letter confirms our concurrence in the Massachusetts Department of Public Works' position as described in the attached letter of May 23, 1968 that the proposed Warren Avenue roadway is a necessary and desirable link in the Federal-aid highway system. This does not represent a commitment of Federal-aid Highway funds to participate in the cost of any construction at the site of the former Warren Avenue bridge.

Very truly yours,



C. T. Garrett
Division Engineer

Attachments



The Commonwealth of Massachusetts

Department of Public Works

100 . Nashua Street . Boston 02114

Proposed North Terminal Area
Improvements-Charlestown Section
of Boston

May 23, 1968

Carleton T. Garrett, Division Engineer
U.S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads
JFK Federal Office Building
Government Center, Room 612
Boston, Massachusetts

Dear Sir:

In answer to your letter of April 17, 1968 on this subject, the Department will in the near future, submit to you a request to place the proposed Warren Avenue Crossing on the Federal-aid Primary System by revising existing Federal-aid Route 5 to coincide with the proposed future directional traffic.

The addition of this proposed crossing to the Federal-aid Primary System is not to be construed as a commitment on our part to participate in any construction at the site of the former Warren Avenue Bridge.

The proposed revision of the route is a necessary link in the Federal-aid Highway System.

Very truly yours,

Daniel S. Horgan
DANIEL S. HORGAN
Chief Engineer

GMJ/mh
C- WTH
GLW
RC



The Commonwealth of Massachusetts

Metropolitan District Commission

20 Somerset Street, Boston 02108

d Whitmore, Jr.

Commissioner

May 23, 1968

Colonel Remi O. Renier
Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

This is in response to the letter from the New England Division, Corps of Engineers dated May 21, 1968, summarizing the conclusions of the Corps' studies of the Lower Charles River. Staff members of the Metropolitan District Commission have closely followed your planning from inception of your studies and the Commission has cooperated by providing essential engineering data developed as the result of the Commission's own studies of the flood control and navigation problems in the Lower Charles.

We are pleased to learn that your conclusions substantiate those of the Commission and that a new dam and pumping plant, along with improved lockage facilities and fishway are economically justified and that there is a substantial Federal interest in construction of the proposed project. We are also gratified that your proposal includes incorporation of a highway viaduct which we desire and need to ease traffic problems within the Commission's area of responsibility.

Of the \$26.5 million cost estimated at 1968 price levels, non-Federal sources would be required to contribute about \$7.9 million as follows: (1) provision of rights-of-way, lands for construction and relocations, including extension of the marginal conduits, about \$3.7 million; (2) provide a cash contribution of 18.2 percent of the construction cost of structures, which means a contribution now estimated at \$4.2 million.

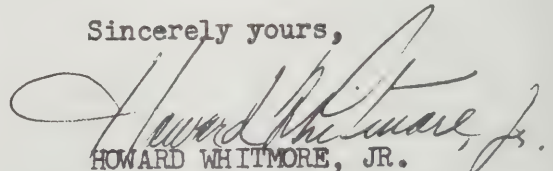
Colonel Remi O. Renier

May 23, 1968

I have been empowered by the Commission at its meeting held today to indicate the concurrence of the Commission in the proposed plan of development and to assure you that the Commission will consider formal action at the appropriate time, consistent with the laws of the Commonwealth, to cooperate in bringing to accomplishment this much needed project and to operate and maintain the project after completion. This would include access between the old and new sites, maintenance of clear waterway openings at the site of the old dam, and preservation of the existing Charles River Basin from additional encroachment.

In closing, I urge you to complete your report as soon as possible so that the Congress can take action on project authorization at an early date.

Sincerely yours,


HOWARD WHITMORE, JR.
Commissioner

HW/o

April 16, 1968

Colonel Remi O. Renier
Corps of Engineers
Department of the Army
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

I enclose copy of the minutes of the meeting held on April 11, of the Citizens Advisory Committee of the Charles River Watershed Study.

You will note that our Committee was unanimously in favor of the MDC proposal to build a new dam downstream the present structure and near the abandoned Warren Avenue bridge. Senator Saltonstall urged that the Corps of Engineers present their study on this dam as soon as possible so that it can be considered in this session of Congress.

I am also advising appropriate people in the Massachusetts State Legislature of our support of this proposal.

Yours very sincerely,

Thomas D. Cabot

TDC:mtd.
Enclosure

CITIZEN ADVISORY COMMITTEE
Minutes of Meeting
April 11, 1968

The New Charles River Dam

The M. D. C. plan for a new Charles River Dam downstream near the abandoned Warren Ave. Bridge was discussed. The engineering consultants, Charles Maguire and Associates, announce that the lower basin would be enlarged by 39 acres and that the pumps could draw 54 million gallons of water a day out of the river. The problem of salt water intrusion would be drastically reduced with three new boat locks. The two hour time lag for a boat to pass through would be speeded up. Such a dam could permit another highway to cross the river. Other benefits from the dam were mentioned. The only factor against the dam is the cost. Senator Saltonstall suggested that the Corps of Engineers submit their study on this dam as soon as possible. A member of Congress can submit the plan early and ask for Federal appropriations. Mr. Lind stated that the Corps of Engineers is working presently to complete this aspect of their study especially on the cost-benefit ratios. Meanwhile, Mrs. Goodhue urged that our support be given to the appropriations of funds for the dam in the State Legislature.

It was moved, seconded, and resolved that Mr. Cabot write the Corps of Engineers to say our committee is in favor of the building of the Dam. We accept, believe and would like to see the plans for the Dam implemented. Also money should be allowed for proper development along the new shoreline of the basin. In addition, Mr. Cabot is to write the appropriate people in the State Legislature such as the Urban Affairs Committee and state our support for the appropriation of adequate funds for the new Charles River Dam.

BOSTON REDEVELOPMENT AUTHORITY

1108 CITY HALL ANNEX, BOSTON, MASSACHUSETTS 02108

March 5, 1968

Mr. John M. Lind
Project Engineer
Charles River Study Units
Building 113 North
U.S. Army Corps of Engineers
424 Tropello Road
Waltham, Massachusetts 02154

Dear Mr. Lind:

Subject: CHARLESTOWN-WARREN DAM BRIDGE

Mr. Blackwell of your office has requested whatever information is available concerning the function of the causeway proposed to be built on top of the Warren Avenue Dam.

The various public agencies have, for sometime, been working together to solve the total transportation problems in this area based on recommendations contained in the 1962 "North Terminal Area Report", which outlined the transportation improvements necessary to complete the expressway and arterial network in the vicinity of Charlestown. The report recommended that Rutherford Avenue be improved and relocated to the B&M railroad yard area (now in final design). The southbound roadway was connected across the Charles River with temporary connections to City Square via a new Warren Dam Bridge and was expected to connect to the Government Center via North Washington Street and to the Central Artery via the Causeway Street on-ramp. The northbound flow to Rutherford Avenue from the Downtown area was expected to use the existing Charlestown Bridge.

Due to the truss which supports the moveable section of the Charlestown Bridge it was felt that sufficient capacity to carry proposed 2-way traffic volumes could not be provided without completely re-building the bridge. This lead to the proposed solution of providing a one-way pair of roadways crossing the river to supply additional capacity and improve the turning conflicts at Causeway Street. All public agencies are presently attempting to implement these various Report recommendations.

If any additional information is needed, please let me know.

Very truly yours,

William T. Noonan
William T. Noonan
Assistant Transportation Coordinator

W R M
William R. McGrath, P.E.
Transportation Coordinator

68-318-0

WTN:ng

EXHIBIT I-8

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